

Traffic Quality on the MAG Regional Freeway System

FINAL REPORT Fall 2001





Prepared by
Skycomp, Inc., Columbia, Maryland, in
association with Olsson Associates
for the
Maricopa Association of Governments

EXECUTIVE SUMMARY

Fall 2001 freeway traffic conditions, and changes since 1998

During the fall of 1998, approximately 110 (centerline) miles of freeway were surveyed in the Phoenix metropolitan area. The method of data capture was overlapping aerial photography, repeated over four morning and four evening commuter survey periods. The output of the survey was a comprehensive assessment of how daily traffic was typically flowing on each surveyed freeway segment, as well as at freeway interchanges and ramps.

This survey was repeated in the fall of 2001 using an identical methodology, with an additional 70 miles of freeway added to the surveyed network. The purpose of this Executive Summary is to compare the results of the 1998 and 2001 surveys with regard to the locations where freeway traffic congestion was found during the peak periods of commuter travel; and to list the primary locations of congestion on those freeways that were surveyed only in 2001.

Many of the aerial photographs from which these findings were derived have been provided in interactive CD-ROM slide shows; these products include not only highlight congestion photographs, but 100% overlapping coverage of each freeway, repeated during both morning and evening peak-hour periods. A digital copy of the final 2001 report has also been provided on the CD-ROM.

For further information about this survey program, or to acquire copies of the CD-ROMs, please contact the Maricopa Association of Governments at 602-452-5021. Skycomp, Inc. conducted the surveys and reports in association with Olsson Associates. Skycomp can be reached at 410-884-6900.

I-10

Additional Coverage: In 2001, the survey limits of I-10 were extended twenty-one miles to the west from Loop 101 to Oglesby Rd, and eight miles to the south from Chandler Blvd to the Pinal County line. No congestion was found along these segments during the 2001 surveys.

Morning:

(Between Loop 101 and Loop 202)

During the 1998 survey, a six-mile zone of eastbound congestion was typically found on I-10 between 75th Ave and I-17; east of I-17, the roadway widened to four lanes and traffic typically flowed at free flow speeds. During the 2001 survey, it appeared the location of congestion shifted to the west due to a different lane configuration on I-10. The roadway was widened from 3 to 4 lanes between the new interchange at Loop 101 and 75th Ave (eastbound); at the 75th Ave interchange the roadway narrowed again to 3 lanes. During the 2001 surveys, congestion approaching the lane drop at 75th Ave typically extended upstream for several miles to the vicinity of 91st Ave; east of 75th Ave, traffic flow gradually improved such that no congestion was found between 59th Ave and I-17.

(Between Loop 202 and Pinal County Line)

During the 1998 and 2001 surveys, northbound congestion was typically found on I-10 approaching the merge with traffic entering at US 60; in 1998, the tail of the queue was typically found several miles upstream in the vicinity of Guadalupe Rd. During the 2001 surveys, congestion approaching US 60 typically extended back to the vicinity of Ray Rd (a distance of approximately five miles). Average speeds through the queue ranged from approximately 20 to 30 mph.

Evening:

(Between Loop 101 and Loop 202)

During the 1998 survey, a four to five mile zone of westbound congestion was typically found on I-10 between 7th St and 43rd Ave; west of 43rd Ave, traffic typically resumed free flow speeds. During the 2001 survey, it appeared the location of congestion shifted to the west due to a different lane configuration on I-10. The roadway was widened from 3 to 4 lanes between 35th Ave and 59th Ave; however, at 59th Ave, the roadway narrowed again to 3 lanes. During the 2001 surveys, congestion approaching the lane drop at 59th Ave typically extended upstream for approximately five miles to the vicinity of I-17; west of the lane drop at 59th Ave, traffic flow improved such that no congestion was found west of 75th Ave.

(Between Loop 202 and Pinal County Line)

During the 1998 and 2001 surveys, a five to six mile zone of eastbound congestion was typically found on I-10 between I-17 and US 60; average speeds ranged from approximately 30 to 50 mph.

I-10 (HOV Lanes)

New Construction / Additional Coverage: Between the 1998 and 2001 aerial surveys, the HOV facility on I-10 was extended one mile to the west, between 91st Ave and the newly constructed interchange at Loop 101.

Morning:

No congestion was found in the I-10 HOV lanes during the morning survey period.

Evenina:

(Between Loop 101 and Loop 202)

During the 2001 survey, intermittent westbound congestion was recorded in the HOV lanes between 16th St and 7th St, and further west between 27th Ave and 43rd Ave; contributing factors to the congestion may have been 1) sun glare and 2) friction between the HOV lane and congested flow in the general purpose lanes. This congestion was not found during the 1998 survey.

I-17

Additional Coverage: In 2001, the northern survey limit on I-17 was extended seventeen miles north of Loop 101 to New River Rd; no congestion was found along this corridor during the morning and evening survey periods.

Morning: During the peak period in 1998 and 2001, southbound congestion was typically found on I-17 between the vicinity of Thunderbird Rd and Indian School Rd; average speeds along this eight-mile corridor ranged from approximately 25 to 45 mph. In 2001, the tail of the queue sometimes extended several miles further north to the vicinity of Bell Rd.

Evening: In 1998 and 2001, similar northbound congestion was found on I-17 between the vicinity of I-10 and Dunlap Ave; average estimated speeds along this seven-mile corridor typically ranged from approximately 20 to 40 mph. In 2001, congestion during the peak period persisted north of Dunlap Ave to the vicinity of Cactus Rd; average estimated speeds here ranged from approximately 30 to 50 mph.

I-17 (HOV Lanes)

New Construction / Additional Coverage: Between the 1998 and 2001 aerial surveys, the HOV facility on I-17 was extended from Dunlap Ave south to I-10, and from Union Hills Dr north to Deer Valley Rd.

Morning & Evening:

No congestion was found in the I-17 HOV lanes during the morning and evening survey periods.

SR 51

New Construction / Additional Coverage: Since the 1998 aerial survey, a newly constructed four-mile section of SR 51 was built between Shea Blvd (northern terminus in 1998) and Bell Rd.

Morning: During the peak period in 1998, southbound congestion was typically found on SR 51 between the vicinity of Northern Ave and Thomas Rd; while southbound congestion found during the 2001 surveys intermittently extended several miles further north, average estimated speeds appeared to improve. Average densities along this corridor in 1998 typically ranged from 55 to 75 pcplpm, corresponding to average estimated speeds of 20 to 40 mph; average densities in 2001 typically ranged from 50 to 60 pcplpm, corresponding to average estimated speeds of 30 to 45 mph.

Evening: In 1998 and 2001, similar northbound congestion was found on SR 51 between I-10 and the vicinity of Glendale Ave. After 5:00 p.m., congestion was particularly severe between I-10 and Camelback Rd where average speeds were estimated at 15 to 30 mph.

US 60

New Construction / Additional Coverage: In 2001, the eastern survey limit on US Rte 60 was extended ten miles east of Power Rd to Goldfield Rd; no congestion was found along this corridor during the morning and evening survey periods. During the 2001 survey period, ongoing construction was found on US 60 between Mill Ave and McClintock Dr, and between Dobson Rd and Val Vista Dr.

Because of the ongoing construction mentioned above it was difficult to determine what congestion on US Rte 60 recorded in 2001 was "normal". While no thru-lanes were closed during the survey periods, the right shoulder was often closed in each direction.

Morning: In the morning, three distinct zones of westbound congestion were found: 1) between Greenfield Rd and Country Club Dr; 2) between Loop 101 and Mill Ave; and 3) at the terminus of US Rte 60 approaching the ramps to Interstate 10.

Evening: In the evening, two distinct zones of eastbound congestion were found: 1) between I-10 and McClintock Dr; and 2) between Loop 101 and Lindsey Rd.

Loop 101-Agua Fria Freeway

New Construction / Additional Coverage:

Since the 1998 aerial survey, a newly constructed five-mile section of Loop 101 was built between Glendale Ave and Interstate 10 (no congestion was found along this corridor during the morning and evening survey periods).

Morning: During the 1998 survey period, no congestion was found on Loop 101 between Glendale Ave and I-17. During the 2001 survey, a short zone of eastbound congestion was intermittently found in the vicinity of 51st Ave; traffic entering at 51st Ave appeared to cause or exacerbate the congestion.

Evening: During the 1998 survey, no congestion was found on Loop 101 (Agua Fria Freeway) between I-10 and I-17. During the 2001 survey, a short zone of westbound congestion was typically found between I-17 and the vicinity of 51st Ave; congestion appeared to be caused by weaving and merging associated with the interchanges along this corridor.

Loop 101-Pima Freeway

New Construction / Additional Coverage: Since 1998, a newly constructed eleven-mile section of Loop 101 was built between I-17 and Scottsdale Rd (no congestion was found along this corridor during the morning and evening survey periods). New construction also included an eleven-mile section between Bell Rd and Thomas Rd, and a five-mile section between US Rte 60 and Chandler Blvd. During the 2001 surveys, the four-mile section of Loop 101 between Scottsdale Rd and Princess Dr was not completed.

Morning: During the 1998 survey period, no congestion was found on Loop 101 (Pima Freeway) between the north and south limits (Thomas Rd and US 60). During the 2001 survey, two distinct zones of northbound congestion were found on the Pima Freeway. An extended zone of northbound congestion was typically found approaching the Loop 202 interchange; traffic exiting in the right lanes at Loop 202 appeared to cause the upstream congestion. The tail of this queue was typically found several miles south of US 60.

North of Loop 202, congestion was typically found approaching the lane drop at McKellips Rd (4 lanes to 3); while congestion persisted north of the lane drop to the vicinity of Thomas Rd, speeds typically improved (35 to 45 mph).

Evening: During the 1998 survey period, no congestion was found on Loop 101 (Pima Freeway) between the north and south limits (Thomas Rd and US Rte 60). During the 2001 survey, two distinct zones of southbound congestion were found on the Pima Freeway approaching the freeway interchanges at Loop 202 and US Rte 60. Congestion approaching Loop 202 typically extended back to the vicinity of Indian Bend Rd (a distance of approximately six miles); the head of this queue was typically found just north of Loop 202 between the interchanges at McDowell and McKellips Rd.

Southbound travelers typically encountered congestion again just south of Loop 202; the head of this queue was found approximately three miles downstream at the lane drop (4 lanes to 2) at US Rte 60; south of US Rte 60, traffic typically flowed freely to the terminus at Chandler Blvd.

SR 143

Morning: During the 1998 and 2001 morning surveys, congestion was not found on SR 143.

Evening: During the 1998 and 2001 surveys, southbound congestion was found at the terminus of SR 143 approaching the ramp to eastbound I-10; densities in the right-hand lanes approaching the I-10 interchange typically ranged from 80 to 55 pcplpm, corresponding to speeds of approximately 20 to 40 mph.

Loop 202

New Construction / Additional Coverage: Since the 1998 aerial survey, a newly constructed one-mile section of Loop 202 was built between Alma School Rd and McKellips Rd (eastern terminus of Loop 202).

Morning: During the 1998 and 2001 surveys, similar westbound congestion was recorded on Loop 202 approaching the terminus at the I-10/SR 51 interchange. During the peak period, congestion typically extended back several miles to the vicinity of 40th St; average speeds here typically ranged from approximately 30 to 45 mph. Westbound congestion was also found between the vicinity of Loop 101 and Mill Ave; while the extent of this congestion was similar during the 1998 and 2001 surveys, duration and severity of the congestion recorded in 2001 increased. Average densities recorded during the 2001 survey ranged from 45 to 60 pcplpm, corresponding to average speeds of approximately 30 to 50 mph.

Evening: During the 1998 survey, eastbound congestion was found on Loop 202 between the vicinity of SR 143 and Mill Ave. This congestion was found again during the 2001 surveys; however, congestion persisted east of Mill Ave for approximately three miles to the Loop 101 Interchange. Traffic merging into the right lanes to exit to Loop 101 southbound appeared to cause the upstream congestion. Average speeds along this five-mile corridor typically ranged from approximately 20 to 40 mph. In the westbound direction, congestion was not found during the 1998 surveys; however, during the 2001 surveys, congestion was found at the terminus of Loop 202 approaching the I-10/SR 51 Interchange. Congestion typically extended back approximately one mile to the vicinity of 32nd St; average speeds ranged from approximately 25 to 35 mph.

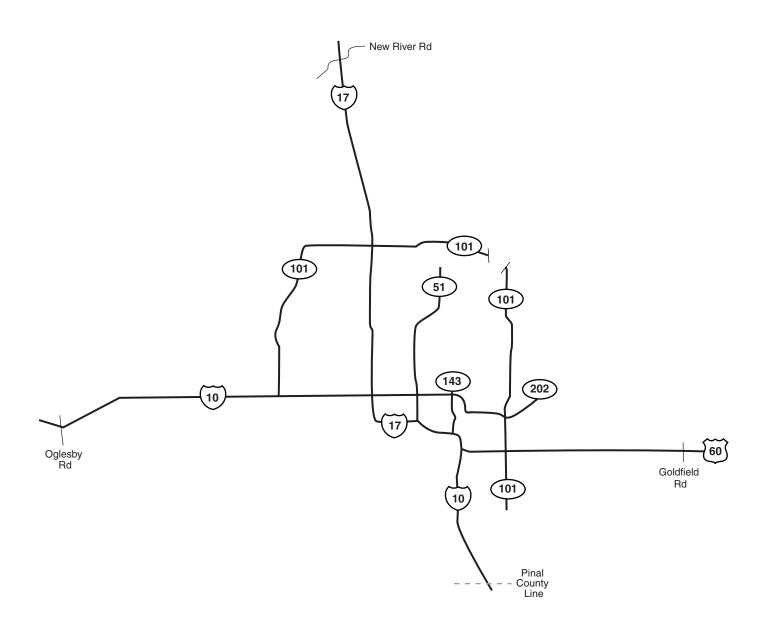
Loop 202 (HOV Lanes)

No congestion was found in the HOV lanes during the morning and evening survey periods.

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SURVEYED FREEWAYS IN THE PHOENIX METROPOLITAN AREA (FALL 2001)



INTRODUCTION

In the fall of 2001, Skycomp conducted a series of aerial photo-surveys of highway traffic conditions in the planning region of the Phoenix metropolitan area. The purpose was to update information on traffic conditions and obtain other materials to support regional planning activities. By repeating survey coverage on a three to five year cycle, long-term trends can be monitored, while the effects of changes on the system can be evaluated. Using the mobility and vantage point of fixed-wing aircraft, a photographic inventory of traffic conditions was made on the backbone of the transportation system; approximately 175 miles of highways were surveyed during the peak morning and evening periods of commuter travel. One of the products of this survey program is a database of traffic conditions on each link of the freeway system, representing average conditions as of fall 2001.

In the fall of 1998, a similar survey of the MAG regional freeway system was conducted, except that only approximately 110 miles of highway were included. The 2001 survey was conducted using the same methodology, except that survey coverage was expanded in the morning and evening:

<u>1998</u> <u>2001</u>

Morning 7:00-9:00 a.m. 6:00-9:00 a.m. Evening 4:00-6:00 p.m. 3:30-6:30 p.m.

Note: The survey program in 1998 included a photographic inventory and queue analysis at approximately 520 intersections in the Phoenix metropolitan area; this task was not repeated in the 2001 survey program.

FEATURES OF THE AERIAL SURVEY PROGRAM

During this aerial survey program, overlapping photographic coverage was obtained of designated freeways, repeated once an hour over four morning and four evening commuter periods. The morning times of coverage were 6:00-9:00 a.m., and evening times were 3:30-6:30 p.m. Survey flights were conducted only on weekdays, except that Monday mornings, Friday evenings and mornings after holidays were excluded. Data were extracted from the aerial photographs such that, by link and by time slice, average recurring daily traffic conditions could be measured. This report presents these measurements in the following ways:

- 1. Performance rating tables of traffic conditions on the 175 miles of surveyed freeways are presented in **Part One** (morning) and **Part Two** (evening) of this report, *on the right-hand side pages*. The ratings are presented in tables by highway segment, by direction and by time slice. Each rating represents the average of approximately four flyovers (from four different days), minus any data affected by incidents (the half-hour time slices represent the average of two flyovers). The ratings are density-based level-of-service (LOS) designations "A", "B", "C", "D", "E" and "F", as defined in the *2000 Highway Capacity Manual* (HCM). The procedures for arriving at the performance ratings have been outlined in **Appendix A**
- 2. Also in **Part One** and **Part Two** of this report, highway maps containing narratives have been placed opposite each performance-rating table, *on the left-hand side*. These narratives clarify the severity and frequency of all congestion found along each highway segment. Where evident, apparent causes of the problems are also described. Congestion on crossing freeways and on interchange ramps are also depicted and discussed.

- 3. In order to allow the estimation of vehicle speeds from densities on the freeways, Skycomp has built a database from data collected in other cities demonstrating the precise relationship between traffic densities and speeds. From this database, a look-up table was developed relating the two variables. The result of Skycomp's work in other cities is provided in **Appendix B**.
- 4. The dates of all survey flights are presented in **Appendix C**. The flight numbers are also provided; these are needed in order to fully interpret the density tables provided in Appendix D.
- 5. Tables showing all individual vehicle density calculations before averaging are provided in **Appendix D**. This appendix contains morning and evening tables with the results of different flights grouped by time slice. Data that were identified for exclusion (due to confirmed or presumed incidents) are also tagged accordingly. This appendix allows a user to investigate density calculations (flight by flight), which underlie each average performance rating. In addition to freeway mainlines, density calculations will also be included in this appendix for all freeway-to-freeway interchange ramps. NOTE: All data values in these tables are truncated density values, in units of 10; for example, a density value of 26 passenger cars per lane-mile is represented by a "2", etc.
- 6. Queue populations at freeway on-ramps (ramp meters) and off-ramps (signal queues) have been recorded for each observation. Each entry also includes physical characteristics of the ramp, including the number of lanes associated with each turning movement. These data will be provided separately on a CD-ROM in .xls format.
- 7. A primary deliverable for this project is an electronic version of the Survey Database (built in Microsoft Access). This database will be functional and contain all of the collected data, from vehicle counts and road segmentation, to flight information and the variables used to calculate densities. Using this database, a number of reports can be displayed or printed, including segment densities (averaged or by individual observation), vehicle classification, and incident information. Since all data is saved in a relational database, it is possible to customize an unlimited number of queries and reports.
- 9. Two interactive CD-ROM products have been prepared in conjunction with the fall 2001 survey program. The first is the **Congestion Highlights** slide show; this product presents the findings of this report, plus many highlight aerial photographs of congestion. This product can be projected to audiences "as is"; the interactive feature allows a presenter to respond to audience interests by going to specific locations as they come up in the discussion. Perhaps more useful is the fact that any graphic or photo in the slide can be "captured" using the "Print-screen" key on the keyboard, and then pasted into custom PowerPoint slide shows for projection, or into word-processed documents for printing or emailing.

The second slide show, the **Peak-Traffic Photolog**, contains overlapping photographic coverage of the entire 175-mile system -- twice. Using actual survey photographs, typical peak-hour passes were selected during both morning and evening survey periods. These passes represent a snapshot of how the highway system looked on a typical day (as much as possible, passes were selected that did not include the effects of major incidents). However, it must be remembered that congestion is an ever-changing phenomenon: some locations are intermittently congested every day, or sometimes throughout one morning but not the next. Also, a location may typically be congested only for a short period of time every day, say only before 7:00 a.m. Thus, when viewing this slide show, keep in mind that the presence or absence of congestion at any specific point does not mean that its always this way. Because

survey findings are based on four mornings and four evenings, the actual report or **Congestion Highlights** slide show must be referenced to get full survey results.

Nevertheless, most problem areas will be well-represented in these photographs; like the other slide show, the **Peak-Traffic Photolog** can be used both interactively in front of an audience, or used as a source of individual photographs for PowerPoint slide shows or printed documents.

ACKNOWLEDGMENTS AND DISCLAIMER

Survey operations would not have been possible without the assistance of regional FAA air traffic controllers. Aircraft were furnished by or contracted through the Southwest Flight Center in Scottsdale, Arizona.

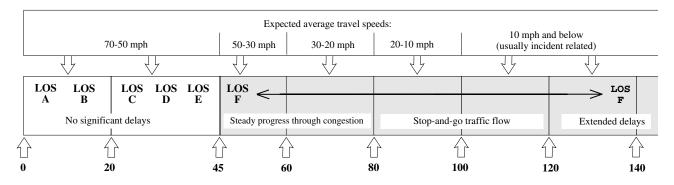
In order to predict average travel speeds from traffic densities, a staff member of the Metropolitan Washington, D.C. Council of Governments (Paul DeVivo) calibrated a single-regime model developed by Michel Van Aerde for use in the metropolitan Washington area. The model was submitted by Van Aerde to the Transportation Research Board in 1995 (TRB Paper No. 95082; see also discussion in Appendix B).

The preparation of this report was financed by the Maricopa Association of Governments. The opinions, findings and conclusions expressed in this report are from Skycomp, not this agency.

QUESTIONS

If there are any questions about this survey program or the underlying methodology, please direct them to Ken Stanek at 410-884-6900.

SUMMARY OF FREEWAY TRAFFIC QUALITY RATINGS (DENSITY-BASED LEVEL-OF-SERVICE)



DENSITY (passenger cars per lane per mile)

These service level definitions are based on the 2000 Highway Capacity Manual

FREEWAY LEVEL-OF-SERVICE RATINGS (UNINTERRUPTED-FLOW FACILITIES):

(NOTE: LEVEL-OF-SERVICE RATINGS ARE BASED ON AVERAGE DENSITIES BETWEEN INTERCHANGES THAT ARE GENERALLY ONE MILE OR GREATER APART. THE EFFECTS OF INCIDENTS AND TEMPORARY ROADWORK HAVE BEEN REMOVED FROM ALL RATINGS BEFORE AVERAGING.)

Level-of-service A: Light traffic flow, at free-flow speeds.

Level-of-service B: Light-to-moderate traffic flow, at free-flow speeds.

Level-of-service C: Moderate traffic flow, usually at free-flow speeds; freedom to maneuver somewhat restricted.

Level-of-service D: Moderate to heavy traffic flow; speeds can be slightly below free-flow; freedom to maneuver significantly restricted.

Level-of-service E: Heavy traffic flow, at speeds typically between 60 and 40 mph. Little or no capacity to absorb additional traffic.

Level-of-service F: Congested traffic flow, with speeds that can range from below 5 mph almost up to 60 mph. For this reason, all "F" ratings have been augmented with average density values, which provide greater insight into the nature of the traffic flow (units are passenger cars per lane-mile):

Densities from 46 to 60: "level-of-service "F" traffic flow averaging approximately 50-30 mph;

Densities from 60 to 80: "slow-then-go" traffic flow (some stopping can occur); traffic flow averaging approximately 40-15 mph;

Densities from 80 to 100: typically associated with "stop-and-go" traffic flow; average travel speeds approximately 25-10 mph. This is the upper boundary that daily congestion is normally measured at.

(Densities above 100 for the full length of a segment usually indicate the presence of an incident or construction.)

Densities from 100 to 120: Average travel speeds typically between 15 and 5 mph. In rare cases, daily congestion can be measured at this level, especially for short bottleneck segments.

Densities from 120 to 180: severe congestion associated with incidents or construction (180 is the highest density measured by Skycomp, with a corresponding average travel speed below 5 mph).

(For more information, refer to "Procedures for determining freeway level-of-service" in Appendix A. These service level definitions are based on the 2000 Highway Capacity Manual.)

$\langle 09 \rangle$ Goldfield Rd CONSTRUCTION ZONES 205 Pinal County Line 143 - New River Rd FREEWAY TRAFFIC QUALITY Congested flow (Estimated average speed 30-50 mph) LOCATIONS WHERE CONGESTION WAS FOUND Morning - Fall 2001 Oglesby Rd

▲ Congested flow (Estimated average speed < 30 mph)</p>

Goldfield Rd **CONSTRUCTION ZONES** 202 Pinal County Line New River Rd 101 LOCATIONS WHERE CONGESTION WAS FOUND Evening - Fall 2001 Oglesby Rd

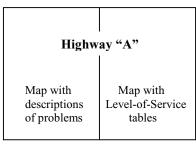
FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

▲ Congested flow (Estimated average speed < 30 mph)</p>

PART ONE

MORNING SURVEY PERIOD



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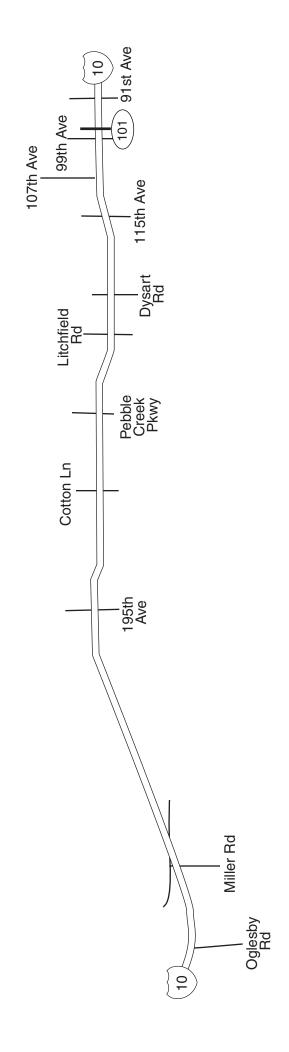
Each highway is presented in a set of opposing maps. The maps with the technical tables on the right contain averaged level-of-service ratings, minus the effects of any known or suspected incidents (actual density values are provided for all LOS "F" ratings). Details are presented in narratives on the left.

Highways are presented in the following order:

•	I-10	10
•	I-10 HOV	16
•	I-17	20
•	I-17 HOV	24
•	SR 51	26
•	US Rte 60	28
•	Loop 101 – Agua Fria Fwy	32
•	Loop 101 – Pima Fwy	34
•	SR 143	
•	Loop 202	42
•	Loop 202 HOV	

I-10 (Between Oglesby Rd & 91st Ave) Morning - Fall 2001

During the morning survey period, no congestion was found on I-10 between Oglesby Rd and 91st Ave.



FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)
Congested flow (Estimated average speed < 30 mph)

91st Ave 134 101 $\mathbf{\omega}$ ⋖ $\mathbf{\omega}$ 99th Ave 133 $\mathbf{\omega}$ 107th Ave 133a 133a 115th Ave LIGHT MODERATE HEAVY CONGESTED

A B C D E F 20 30 40 50 Density scale (cars per lane-mile) $\mathbf{\omega}$ m $\mathbf{\omega}$ $\mathbf{\omega}$ 131 131 ⋖ $\mathbf{\omega}$ $\mathbf{\omega}$ $\mathbf{\omega}$ $\mathbf{\omega}$ $\mathbf{\omega}$ LEVEL-OF-SERVICE LEGEND: Dysart Rd 129 129 Litchfield Rd ⋖ $\mathbf{\omega}$ $\mathbf{\omega}$ $\mathbf{\omega}$ 9 128 128 ⋖ $\mathbf{\omega}$ \mathbf{m} ⋖ $\mathbf{\omega}$ Pebble Creek Pkwy 126 126 WESTBOUND ⋖ ⋖ $\mathbf{\omega}$ ⋖ ⋖ Cotton Ln 124 124 ⋖ ⋖ ⋖ ⋖ ⋖ 195th Ave **EASTBOUND** 121 121 ⋖ ⋖ ⋖ ⋖ Miller Rd ⋖ ⋖ ⋖ Oglesby Rd 112 6:00 a.m. 6:00 a.m. 6:30 a.m. 7:30 a.m. 8:30 a.m. 9:00 a.m. 6:30 a.m. 7:30 a.m. 8:30 a.m. 9:00 a.m. 10 11

(Between Oglesby Rd & 91t st Ave)

Morning - Fall 2001

I-10□ (Between 91st Ave & Loop 202 / SR 51) Morning - Fall 2001

After 8:00 a.m., congestion was typically found on the westbound exit ramp at 7th St, at its maximum observed extent, congestion in the exit lane extended back to the vicinity of 16th St.

During the peak period, westbound congestion was typically found on the freeway ramp from Loop 202 to I-10; this congestion appeared to be caused or exacerbated by weaving west of the SR 51/Loop 202/ I-10

51 interchange. 16th St St Ath Ave 9th Ave 27th Ave vicinity of 16th St. 35th Ave 43rd Ave 51st Ave 59th Ave 75th Ave 83rd Ave

202

During the peak period, eastbound congestion was found on I-10 between 91st Ave and 59th Ave; average estimated speeds along this segment ranged from approximately 20 to 40 mph. Factors contributing to the congestion were 1) the lane drop (5 lanes to 4) at 83rd Ave and 2) the lane drop (4 lanes to 3) at 75th Ave.

at the signal.

congestion was found on 51st eastbound congestion was found on 51st Ave approaching the signal at I-between I-17 and 7th Autority and 7th Autority 20 to 25 vehicles approximately 20 to 25 vehicles congestion approximately 20 to 25 vehicles congestion approximately 20 to 25 vehicles congestion appeared the felt-turn lane congesti

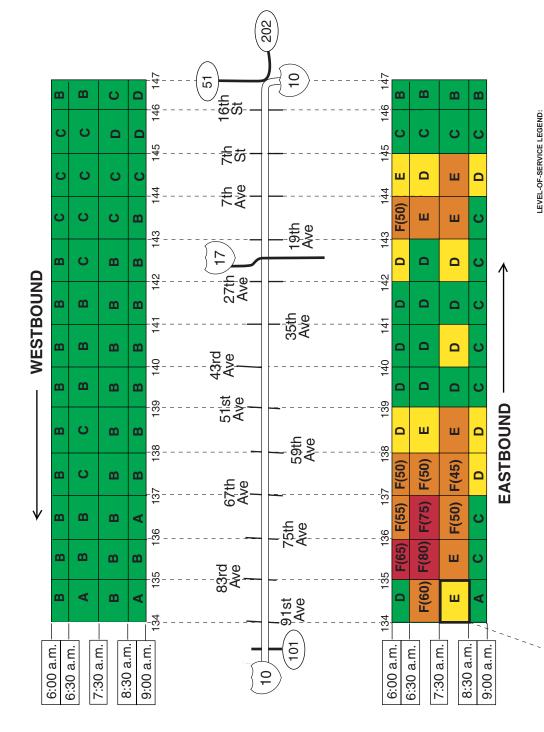
On some days but not others, a short zone of eastbound congestion was found on 1-10 between 1-17 and 7th Ave; when congested, average estimated speeds along this segment ranged from approximately 40 to 50 mph. Congestion appeared to be caused or exacerbated by the lane drops (5 lanes to 4 and 4 lanes to 3) in the vicinity of 7th Ave.

FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

I-10□ (Between 91st Ave & Loop 202 / SR 51) Morning - Fall 2001

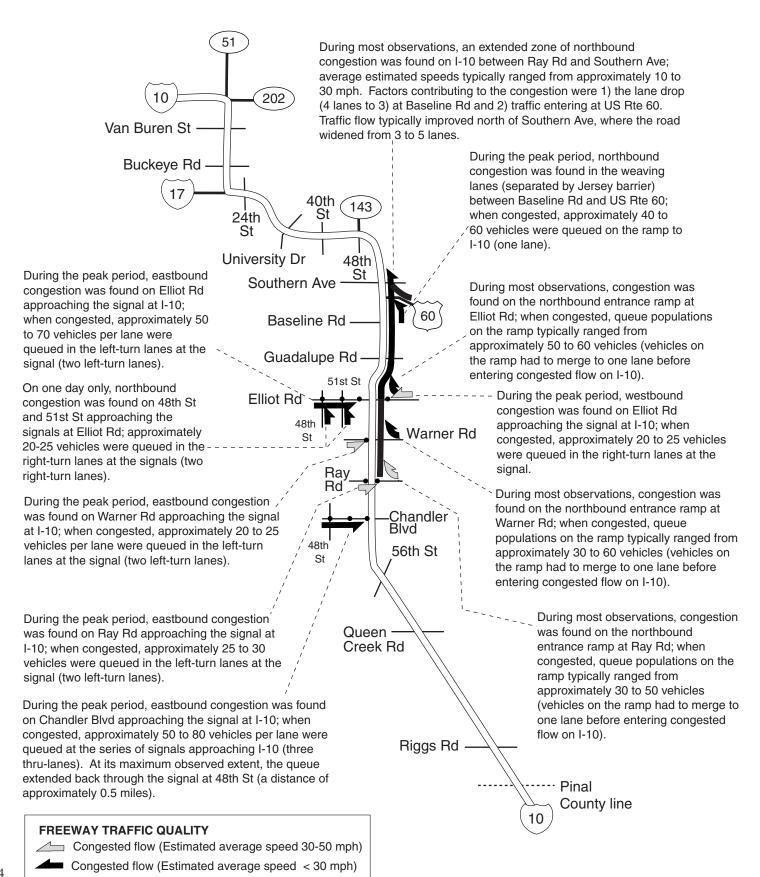


These level-of-service ratings represent the mathematical average of densities, which varied during this hour (congested/not congested); when congested, densities ranged widely, between 90 and 45 pcplpm with corresponding speed estimates of 20 to 50 mph.

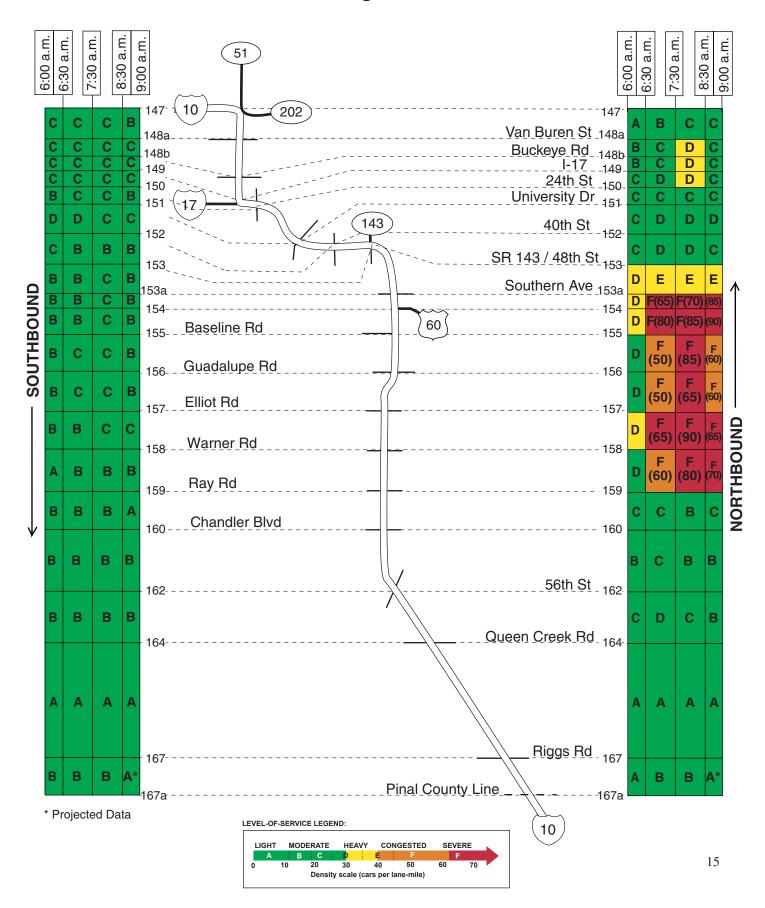
LIGHT MODERATE HEAVY CONGESTED

20 30 40 50 Density scale (cars per lane-mile)

I-10 (Between Loop 202 / SR 51 & Pinal County Line) Morning - Fall 2001

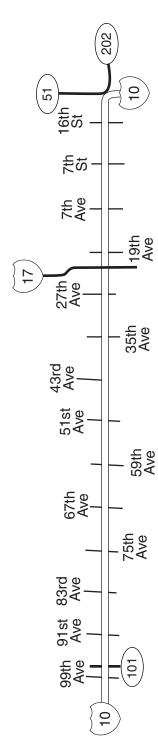


I-10 (Between Loop 202 / SR 51 & Chandler Blvd) Morning - Fall 2001



I-10 HOV (Between 99th Ave & Loop 202 / SR 51) Morning - Fall 2001

During the morning survey period, no congestion was found in the I-10 HOV lanes between 99th Ave and Loop 202 / SR 51.

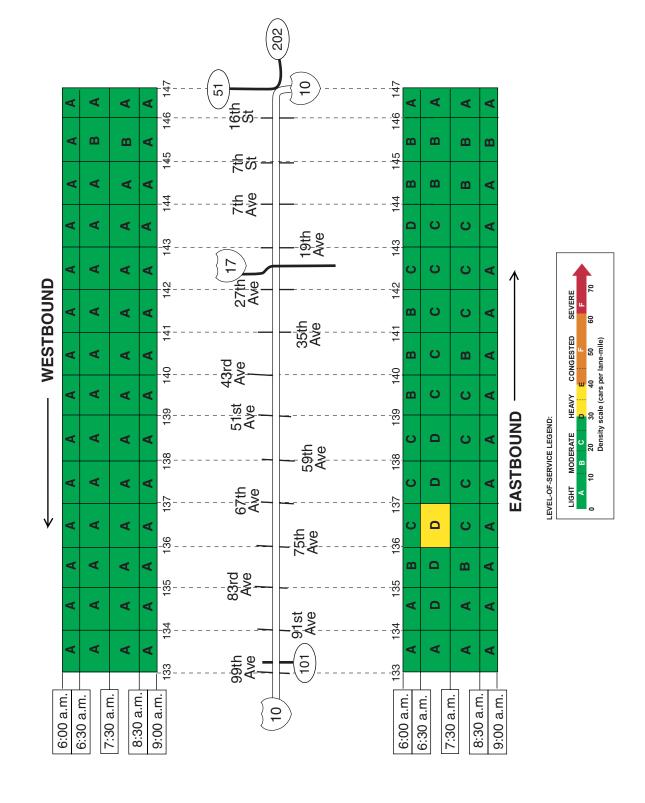


FREEWAY TRAFFIC QUALITY

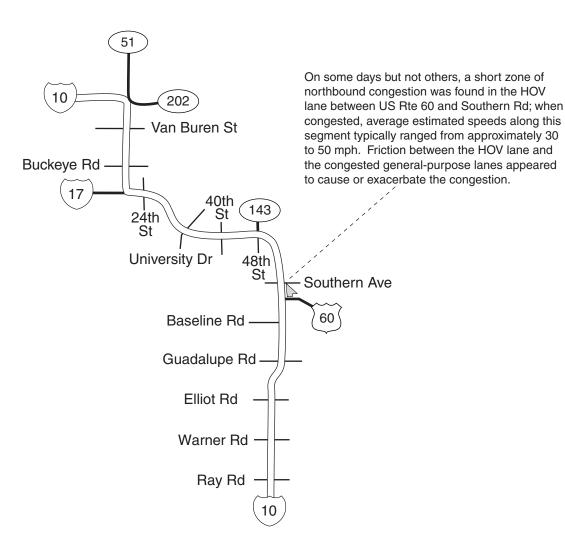
Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

I-10 HOV (Between 99th Ave & Loop 202 / SR 51) Morning - Fall 2001



I-10 HOV (Between Loop 202 / SR 51 & Ray Rd) Morning - Fall 2001

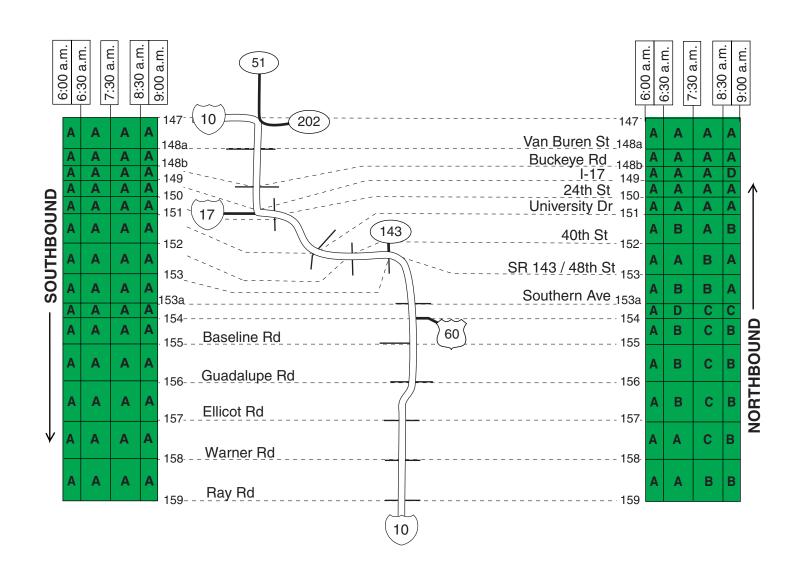


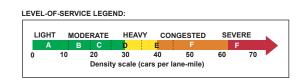
FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

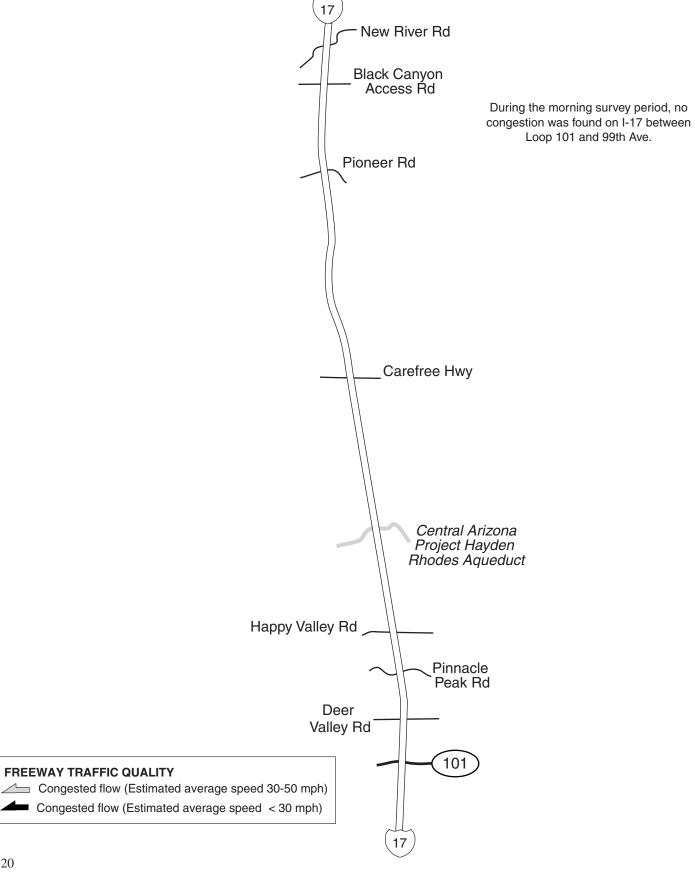
Congested flow (Estimated average speed < 30 mph)

I-10 HOV (Between Loop 202 / SR 51 & Ray Rd) Morning - Fall 2001

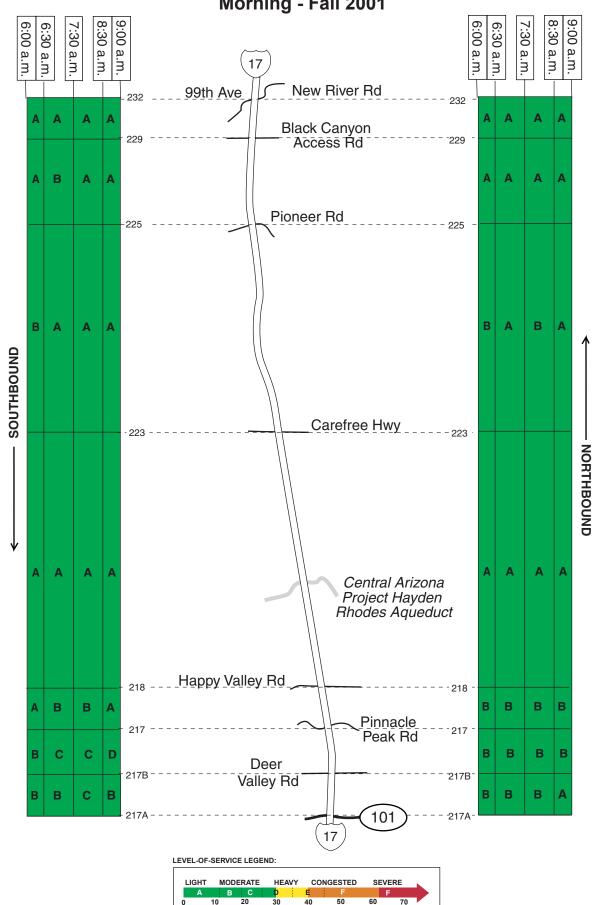




I-17 (Between 99th Ave & Loop 101) Morning - Fall 2001

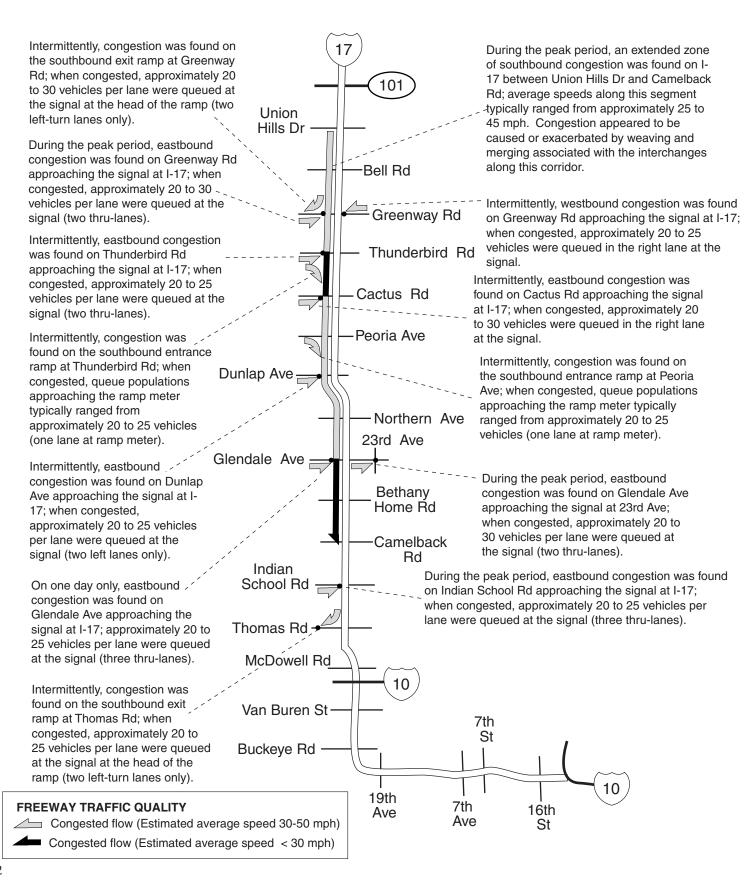


I-17 (Between 99th Ave & Loop 101) Morning - Fall 2001

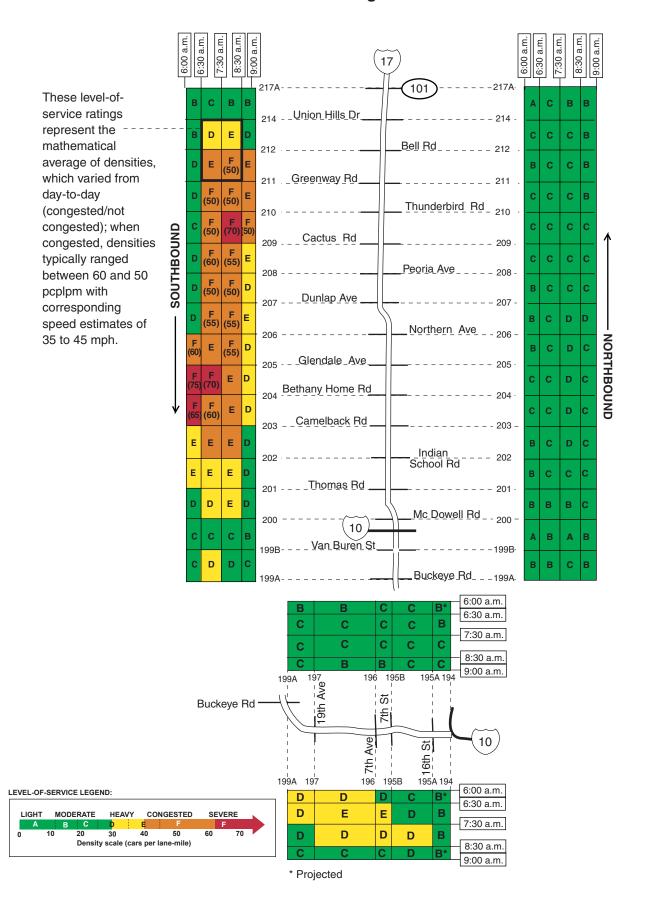


Density scale (cars per lane-mile)

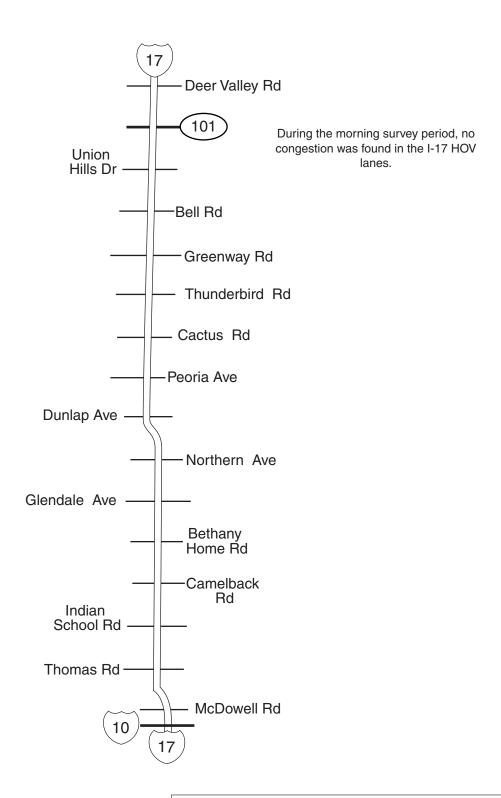
I-17 (Between Loop 101 & I-10) Morning - Fall 2001



I-17 (Between Loop 101 & I-10) Morning - Fall 2001



I-17 HOV Morning - Fall 2001

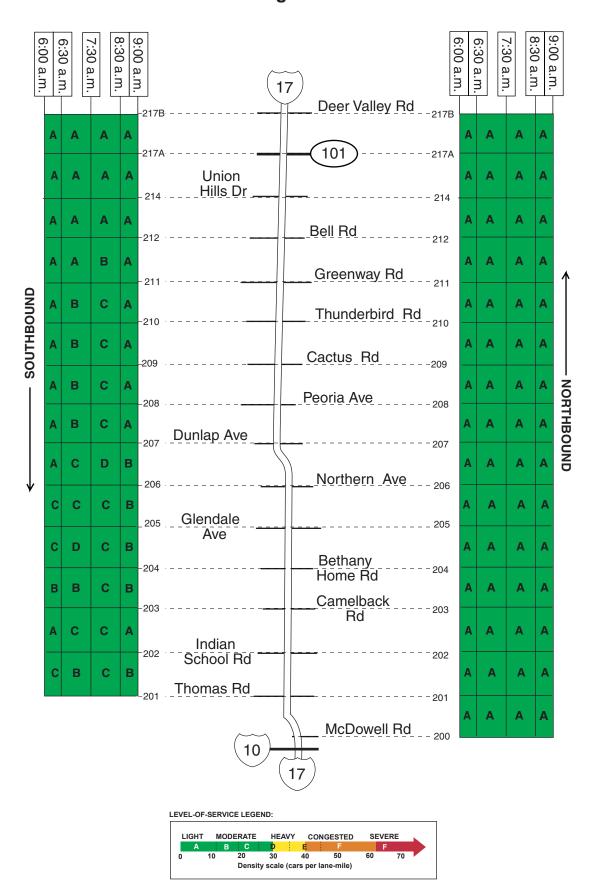


FREEWAY TRAFFIC QUALITY

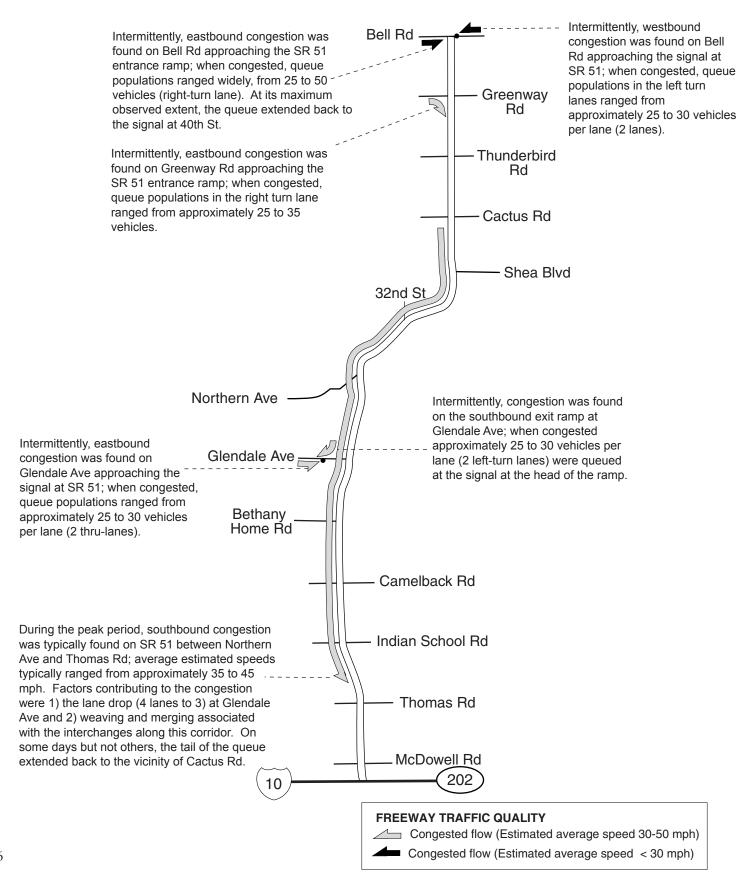
Congested flow (Estimated average speed 30-50 mph)

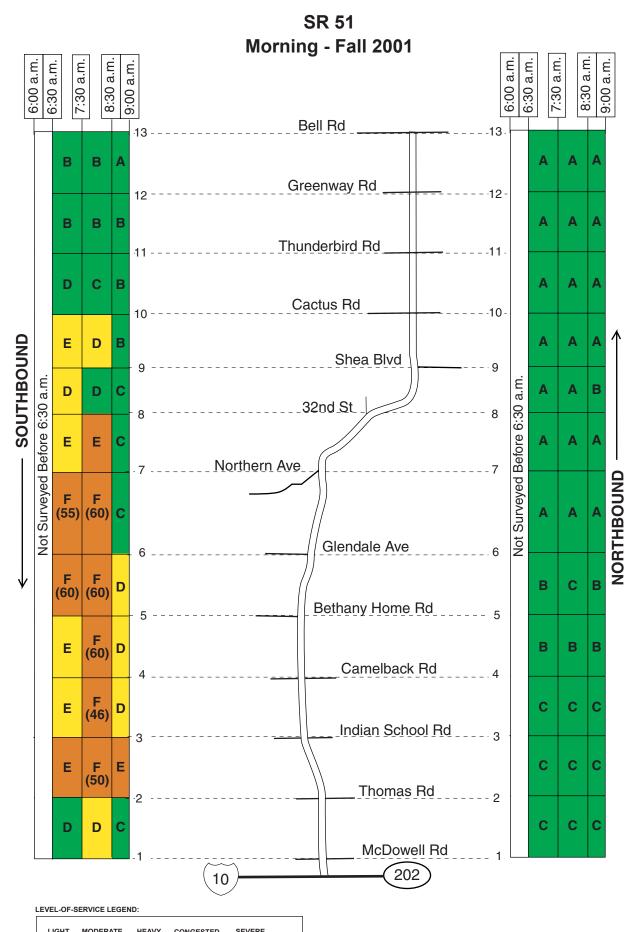
Congested flow (Estimated average speed < 30 mph)

I-17 HOV (Between Deer Valley Rd & McDowell Rd) Morning - Fall 2001



SR 51 Morning - Fall 2001





C D E F
20 30 40 50
Density scale (cars per lane-mile)

Intermittently, congestion was found on the westbound entrance ramp at Mill Ave; when congested, queue populations approaching the ramp meter ranged from approximately 20 to 25 vehicles (one lane at ramp meter).

(Between I-10 & Higley Rd)

US ROUTE 60

Morning - Fall 2001

During the peak period, westbound congestion was found on US Rte 60 approaching I-10; average estimated speeds ranged widely, from approximately 25 to 45 mph. The merge into congested flow on I-10 appeared to cause or exacerbate the congestion.

During most observations, westbound congestion was found on US Rte 60 between Loop 101 and Mill Ave; average estimated speeds along this segment typically ranged from approximately 15 to 25 mph. Ongoing construction between McClintock Dr and Mill Ave may have exacerbated the congestion (right shoulder closed).

Intermittently, congestion was found on the westbound entrance ramp at Mesa Dr; when congested, queue populations approaching the ramp meter ranged from approximately 20 to 25 vehicles per lane (two lanes at ramp meter).

During most observations, congestion was found on the westbound entrance ramp at Stapley Dr; when congested, queue populations approaching the ramp meter typically ranged from approximately 25 to 35 vehicles (one lane at ramp meter).

During most observations, congestion was found on the westbound entrance ramp at Gilbert Rd; when congested, queue populations approaching the ramp meter ranged widely, from approximately 20 to 50 vehicles (one lane at ramp meter).

Intermittently, congestion was found on the westbound entrance ramp at Val Vista Dr; when congested, queue populations approaching the ramp meter typically ranged from approximately 20 to 25 vehicles (one lane at ramp meter).

Greenfield Bg Vista Dr -indsay Gilbert Rd CONSTRUCTION ZONE Stapley Mesa School Dobson Bo McClintock CONSTRUCTION ZONE

Higley Rd

During the peak period, westbound congestion was found on US Rte 60 between Greenfield Rd and Country Club Dr. Ongoing construction between Val Vista Dr and Dobson Rd may have exacerbated the congestion (right shoulder closed). Average speeds along this segment typically ranged from approximately 20 to 30 mph. Traffic flow consistently improved west of Country Club Dr, where the road widened from 3 to 4 lanes.

Intermittently, northbound congestion was found on Mesa Dr approaching the signal at US Rte 60; when congested, approximately to 30 vehicles were queued in the left lane at the signal.

Intermittently, northbound congestion was found on Gilbert Rd approaching the signal at US Rte 60; when congested, approximately 25 to 35 vehicles were queued in the left lane at

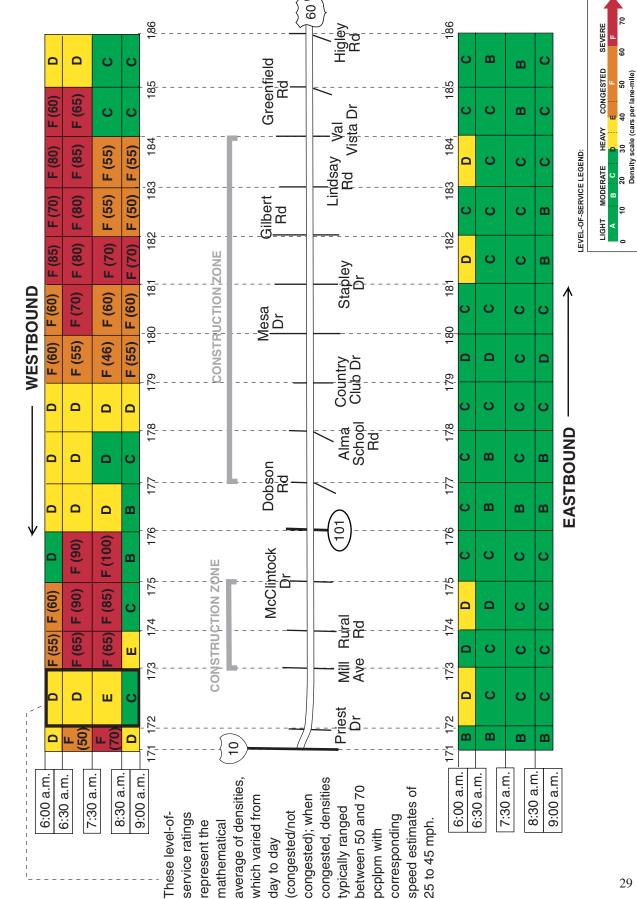
the signal.

signal.

FREEWAY TRAFFIC QUALITY

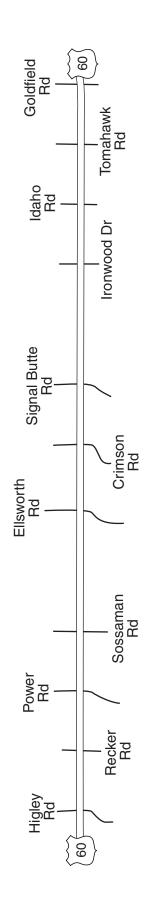
Congested flow (Estimated average speed 30-50 mph)
 Congested flow (Estimated average speed < 30 mph)

(Between I-10 & Higley Rd) Morning - Fall 2001 **US Route 60**



(Between Higley Rd & Goldfield Rd) Morning - Fall 2001 **US ROUTE 60**

During the morning survey period, no congestion was found on US Rte 60 between Higley Rd and Goldfield Rd.

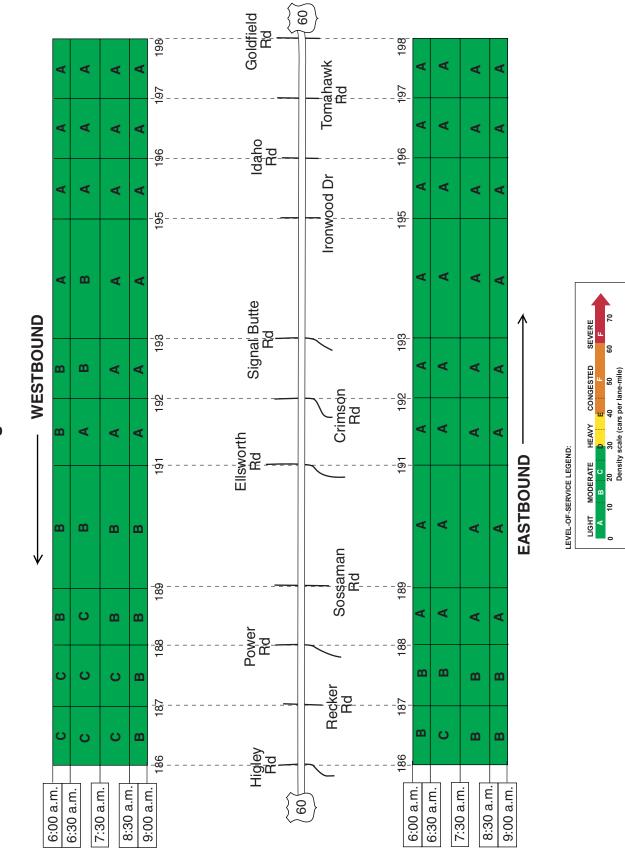


FREEWAY TRAFFIC QUALITY

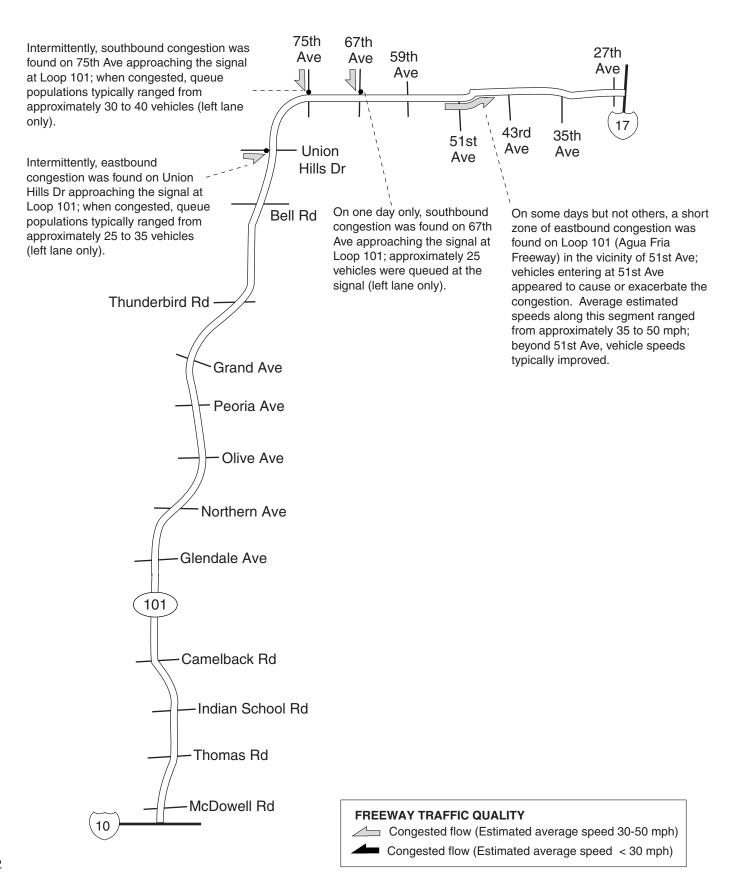
Congested flow (Estimated average speed 30-50 mph)

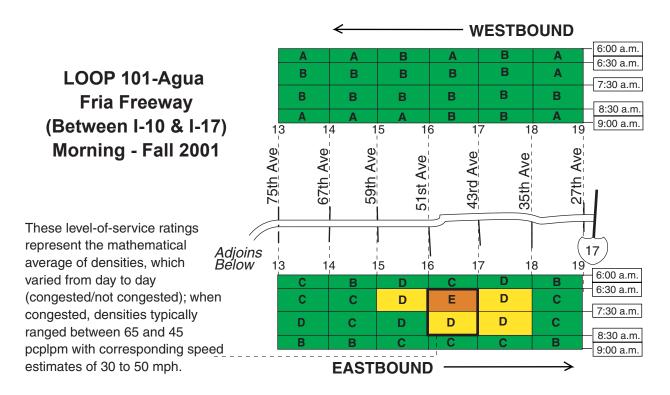
■ Congested flow (Estimated average speed < 30 mph)</p>

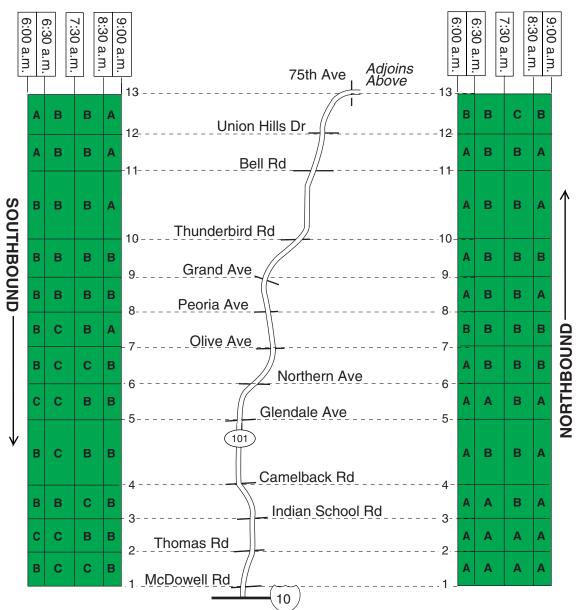
US Route 60 (Between Higley Rd & Goldfield Rd) Morning - Fall 2001



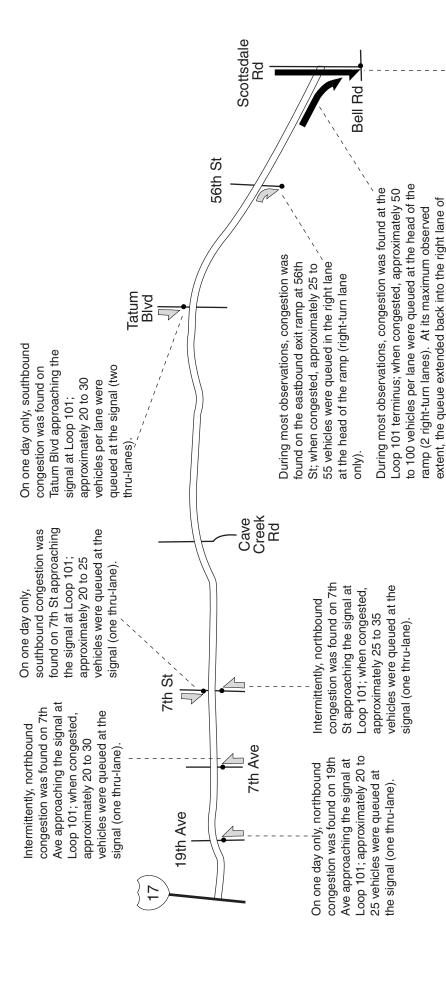
LOOP 101 - Agua Fria Freeway (Between I-10 & I-17) Morning - Fall 2001







Loop 101 - Pima Freeway (Between I-17 & Scottsdale Rd) Morning - Fall 2001



FREEWAY TRAFFIC QUALITY

Loop 101.

through the signals at Princess Blvd, Mayo

Blvd, and Loop 101 (a distance of

approximately 2 miles).

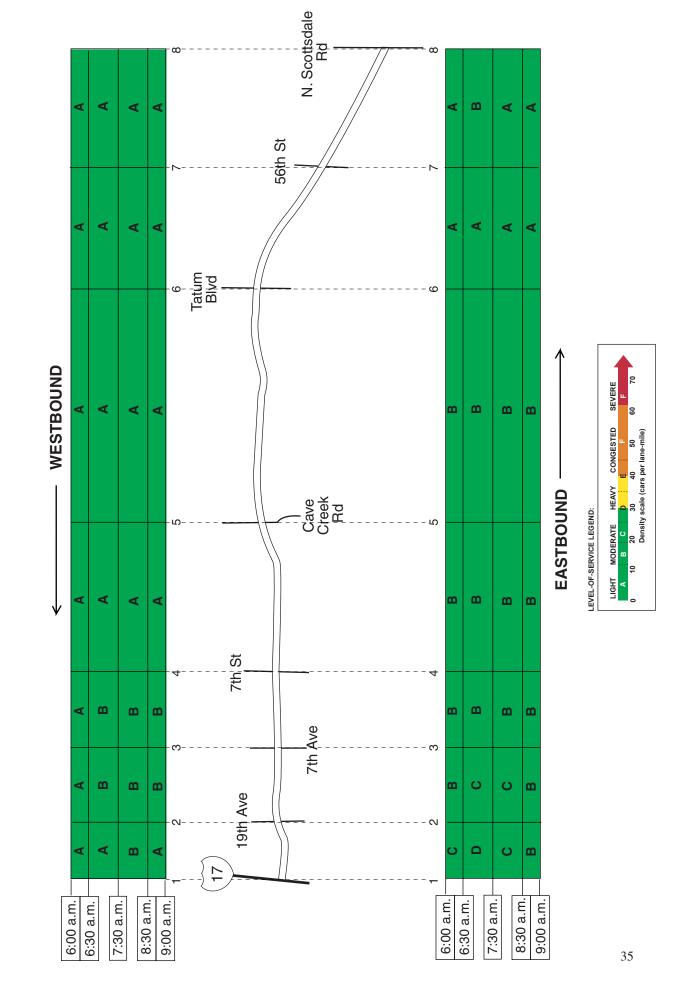
During most observations, southbound congestion was found on Scottsdale Rd approaching the signal at Bell Rd; when

congested, the queue extended back

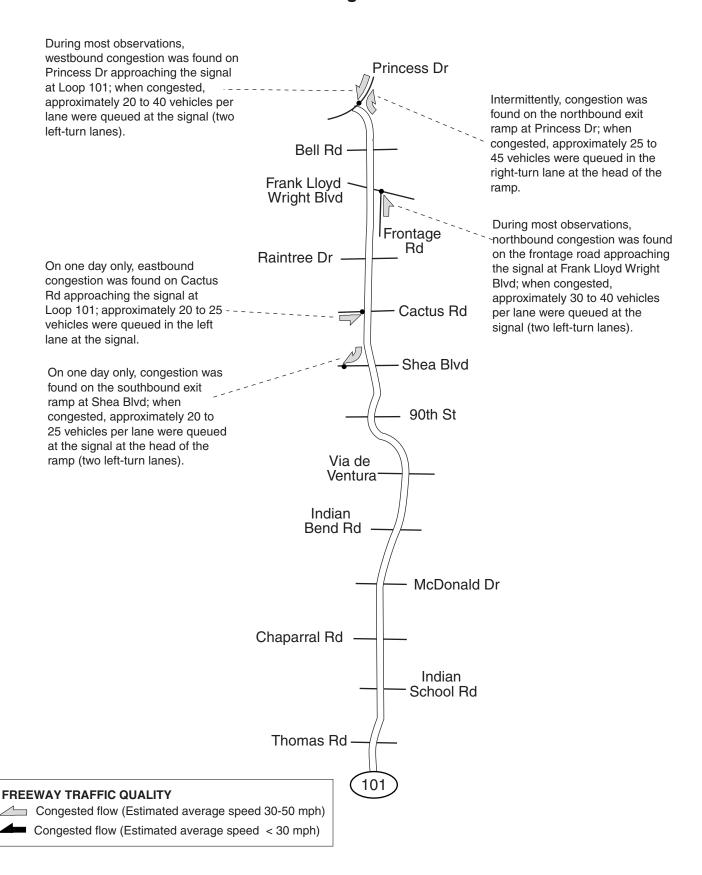
Congested flow (Estimated average speed 30-50 mph)

■ Congested flow (Estimated average speed 50.30 mph)

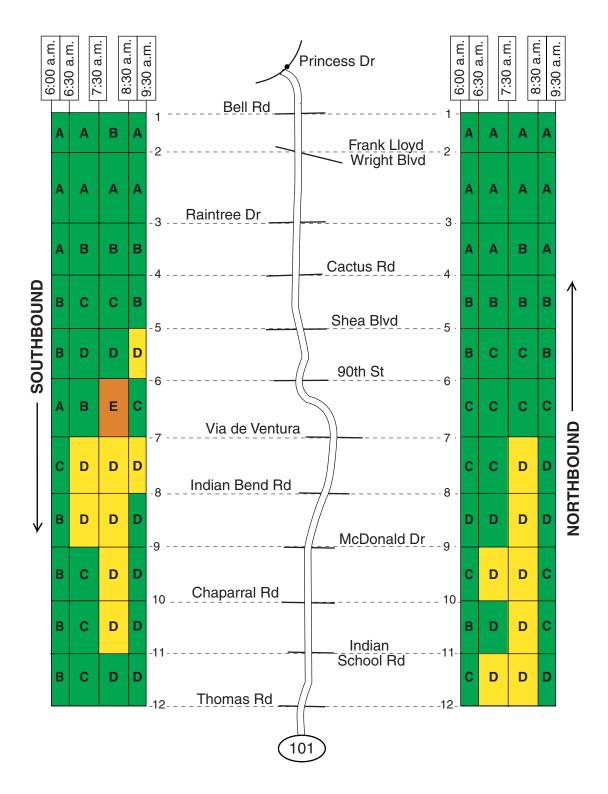
Loop 101-Pima Freeway (Between I-17 & N. Scottsdale Rd) Morning - Fall 2001

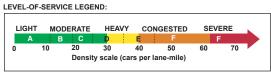


Loop 101 - Pima Freeway (Between Princess Dr & Thomas Rd) Morning - Fall 2001

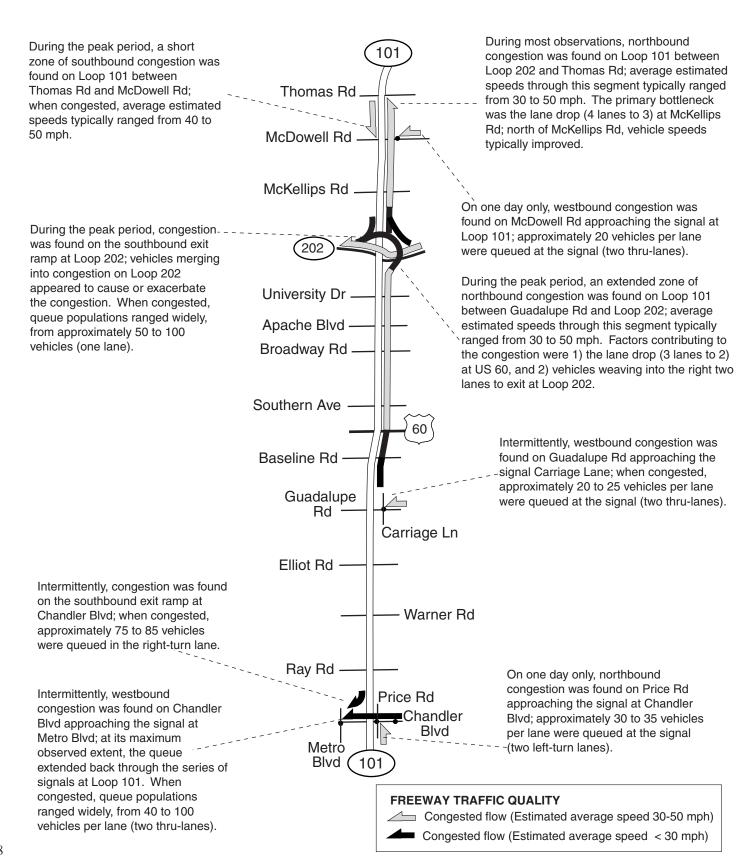


Loop 101-Pima Freeway (Between Princess Dr & Thomas Rd) Morning - Fall 2001

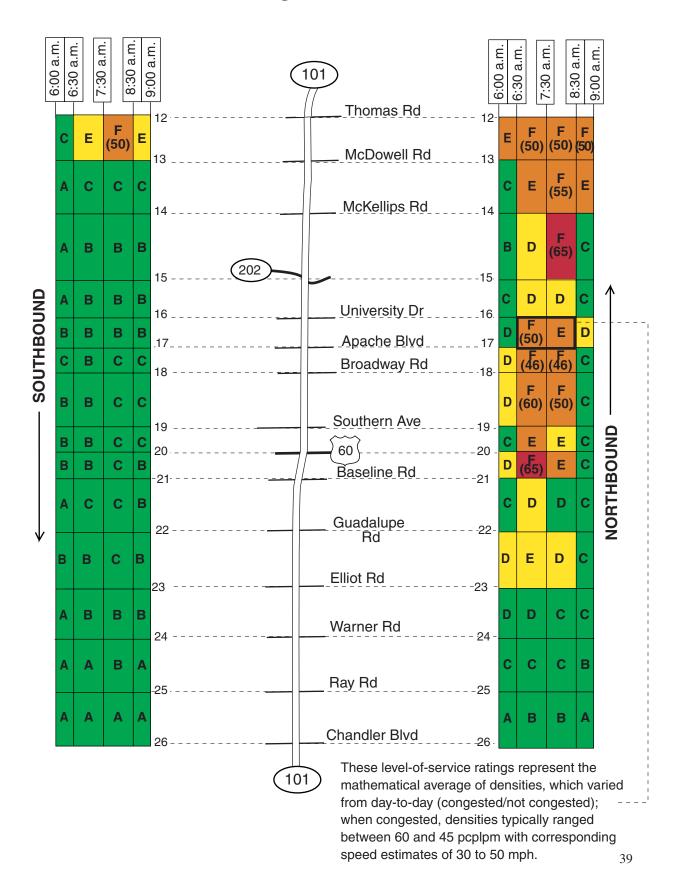




Loop 101 - Pima Freeway (Between Thomas Rd & Chandler Blvd) Morning - Fall 2001

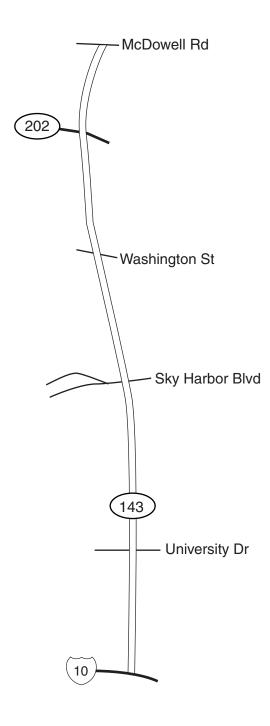


Loop 101-Pima Freeway (Between Thomas Rd & Chandler Blvd) Morning - Fall 2001



SR 143 Morning - Fall 2001

No congestion was found on Rte 143 during the morning survey period.



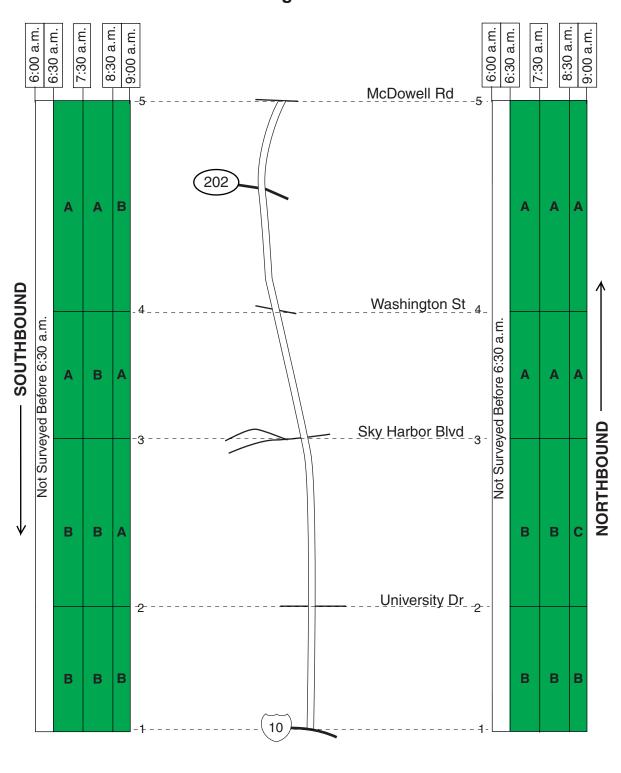
FREEWAY TRAFFIC QUALITY

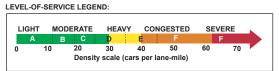


Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

SR 143 Morning - Fall 2001





Loop 202

Alma School McKellips Rd. Freeway) and Mill Ave; average estimated speeds typically ranged from approximately 30 to 50 mph. This congestion appeared to be caused or exacerbated by weaving and During most observations, westbound congestion was typically found on Loop 202 between Loop 101 (Pima corridor. At its maximum observed extent, the queue merging associated with the interchanges along this 101 extended back onto Loop 101. McClintock Dr Morning - Fall 2001 Mill Ave - Van Buren St congestion was typically found on Loop During most observations, westbound I-10; this congestion appeared to be During the peak period, westbound the freeway ramp from Loop 202 to caused or exacerbated by weaving congestion was typically found on west of the SR 51/Loop 202/ I-10 40th St 32nd St Interchange. 24th St

During the peak period, westbound congestion was found on McKellips Rd approaching the signal at back through the signals at Country Club Dr and Loop 202; when congested, the queue extended Center St (a distance of approximately 1 mile).

Dobson Rd

Scottsdale Rd

Priest Dr

202 between SR 143 and I-10 / SR 51;

average estimated speeds typically ranged from approximately 30 to 45

anes to 3) at 32nd St and 2) the lane

drop (3 lanes to 2) at I-10 / SR 51.

congestion were 1) the lane drop (4

mph. Factors contributing to the

FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

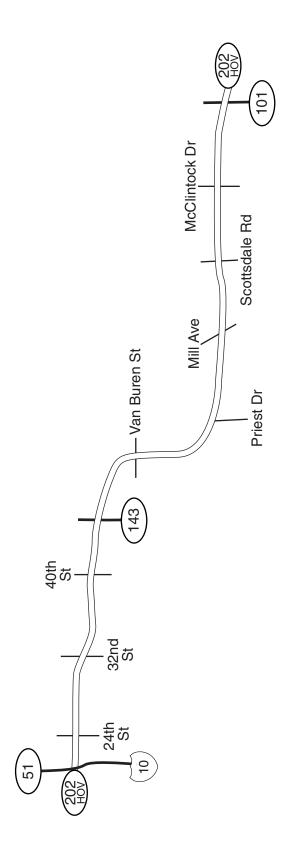
Congested flow (Estimated average speed < 30 mph)

McKellips Rd ⋖ $\mathbf{\omega}$ Alma School Rd LIGHT MODERATE HEAVY CONGESTED

A B C D E F
0 10 20 30 40 50
Density scale (cars per lane-mile) O Dobson Rd 9 O ⋖ **a** O $\mathbf{\omega}$ EVEL-OF-SERVICE LEGEND: Loop 101 101 F (46) ⋖ McClintock Dr F (50) F (60) m \mathbf{m} m \mathbf{m} Scottsdale Rd Morning - Fall 2001 WESTBOUND F (50) F (60) **Loop 202** \mathbf{m} \mathbf{m} $\mathbf{\omega}$ Mill Ave **a** \mathbf{m} $\mathbf{\omega}$ $\mathbf{\omega}$ ۵ 56th St **EASTBOUND** O ш O Van Buren St _ 4 \mathbf{m} <u>*</u> O O * O 40th St 2A F (50) ۵ 32nd St Projected F (60) ш ۵ - - 24th St-7:30 a.m. 8:30 a.m. 6:30 a.m. 7:30 a.m. 21 9:00 a.m. 6:30 a.m. 8:30 a.m. 9:00 a.m. 6:00 a.m. 43

Loop 202 HOV Morning - Fall 2001

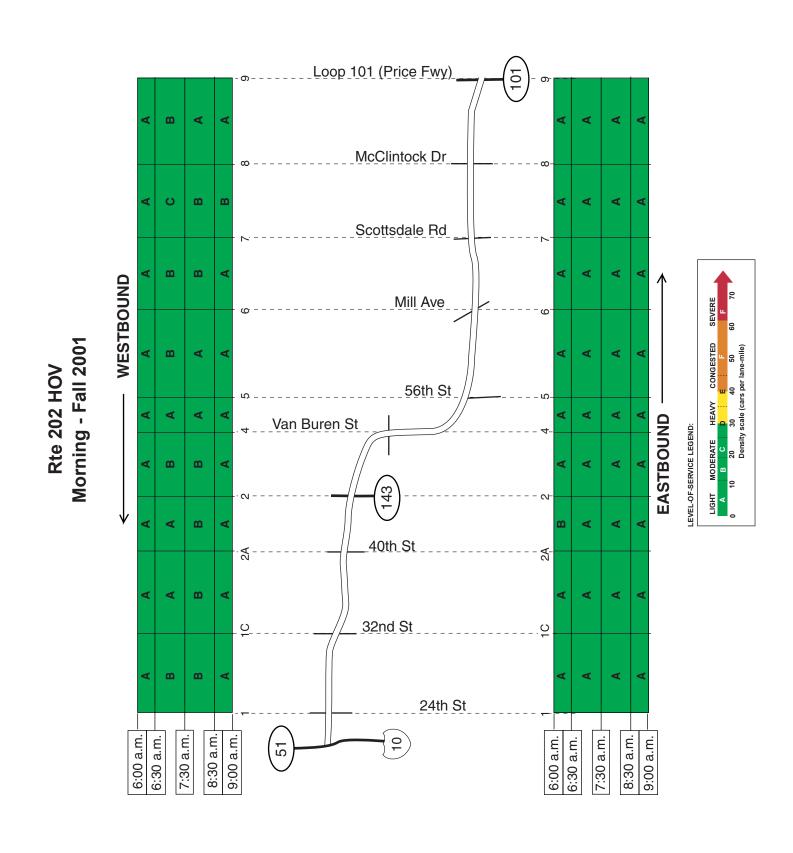
During the morning survey period, no congestion was found in the Loop 202 HOV lanes.



FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph) ▲ Congested flow (Estimated average speed < 30 mph)</p>

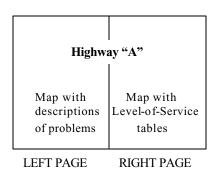
44



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PART TWO

EVENING SURVEY PERIOD

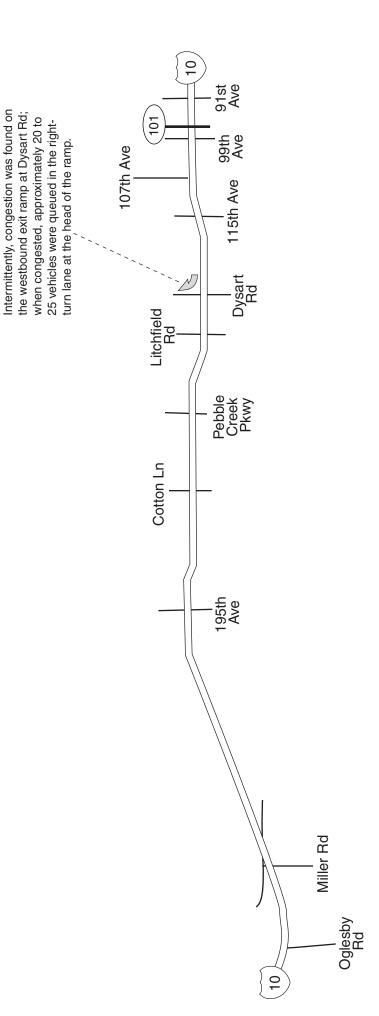


Each freeway is presented in a set of opposing maps. The maps with the technical tables on the right contain averaged level-of-service ratings, minus the effects of any known or suspected incidents (actual density values are provided for all LOS "F" ratings). Details are presented in narratives on the left.

Freeways are presented in the following order:

•	I-10	48
•	I-10 HOV	54
•	I-17	58
•	I-17 HOV	62
•	SR 51	64
•	US Rte 60	66
•	Loop 101 – Agua Fria Fwy	70
•	Loop 101 – Pima Fwy	
•	SR 143	78
•	Loop 202	80
•	Loop 202 HOV	82

I-10 (Between Oglesby Rd & 91st Ave) Evening - Fall 2001

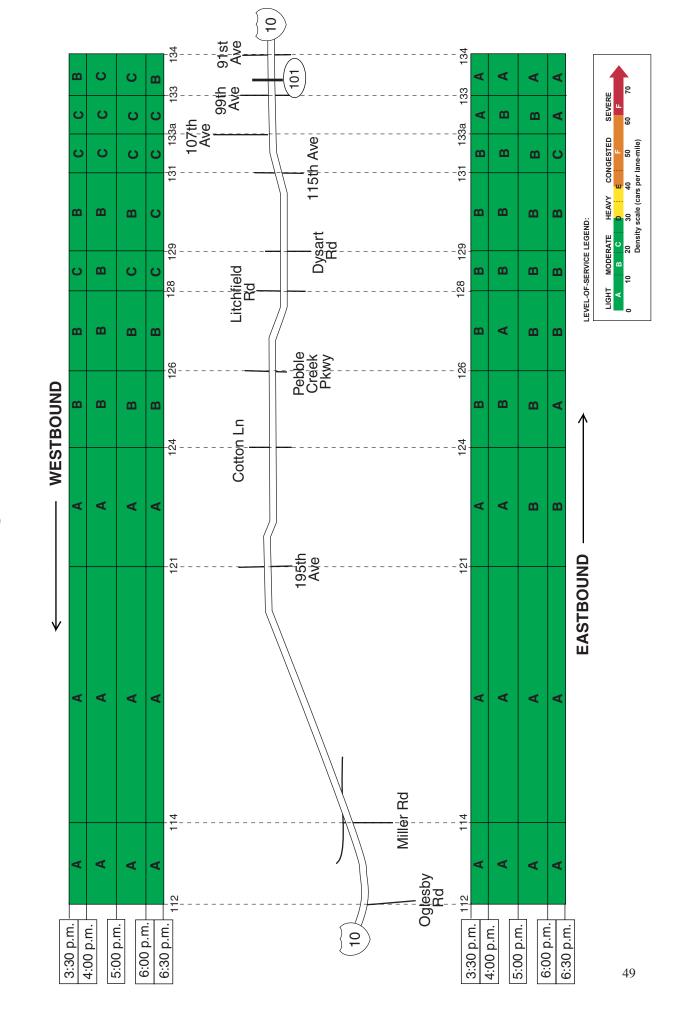


FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)</p>

I-10 (Between Oglesby Rd & 91st Ave) Evening - Fall 2001



(Between 91st Ave & Loop 202 / SR 51) Evening - Fall 2001

Intermittently, congestion was found on the westbound exit ramp at 75th vehicles were queued in the rightturn lane at the head of the ramp Ave; approximately 30 to 35

approximately 40 to 80 vehicles were Intermittently, congestion was found on the westbound entrance ramp at queued at the ramp meter on the 7th Ave; when congested,

On one day only, southbound congestion was found on 7th St approaching the vehicles per lane were queued at the signal at I-10; approximately 20 to 25 signal (two left-turn lanes only).

queued at the signal at the head of the ramp (two left-turn lanes only). 20 to 30 vehicles per lane were

Intermittently, congestion was found

St; when congested, approximately

on the westbound exit ramp at 7th

16th St 19th Ave 27th Ave 35th Ave 43rd Ave ramp (one thru-lane at ramp meter). 51st Ave 59th Ave 67th Ave 75th Ave 83rd Ave 91st Ave

51

During the peak period, westbound congestion was found on I-10 between the vicinity of I-17 and 67th Ave. Contributing factors to and 2) the lane drop (4 lanes to 3) at 59th Ave. Average speeds along this segment typically ranged from approximately 20 to 40 the congestion were 1) the lane drop (5 lanes to 4) at 35th Ave,

St; average estimated speeds along this segment typically ranged from 30 to 50 drops (5 lanes to 4 and 4 lanes to 3) in westbound congestion was found on I-10 between SR 51 / Loop 202 and 7th mph. This congestion appeared to be caused or exacerbated by the lane Before 4:30 p.m., a short zone of he vicinity of 7th St.

eastbound congestion was

typically found on the

Juring the peak period,

freeway ramp from I-10 to Loop 202; this congestion appeared to be caused or exacerbated by weaving

east of the SR 51/Loop

202/ I-10 Interchange.

congested, approximately 30 to 35 vehicles Intermittently, congestion was found on the eastbound entrance ramp at 7th St; when per lane were queued at the ramp meter (two thru-lanes at ramp meter).

FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph) Congested flow (Estimated average speed < 30 mph)

estimates of 40 to 50 mph. congested densities in the right lane approaching the estimates of 40 to 50 mph. widely between right- and typically ranged between mathematical average of mathematical average of densities, which varied 55 and 45 pcplpm with densities, which varied These level-of-service These level-of-service left-hand lanes. When corresponding speed ratings represent the congested, densities ratings represent the SR 51/Loop 202/I-10 corresponding speed Interchange ranged between 55 and 45 congested); when from day-to-day (congested/not pcplpm with 202 147 21 O Ö O O 16th $\mathbf{\omega}$ 146 146 ш ш ₽ts 145 ш Ш ۵ 7th Ave 144 (Between 91st Ave & Loop 202 / SR 51) O O 19th Ave 143 F(55) Ш O O SEVERE WESTBOUND 142 F(55) O Evening - Fall 2001 \mathbf{m} 35th Ave LIGHT MODERATE HEAVY CONGESTED 141 20 30 40 50 Density scale (cars per lane-mile) F(60) F(60) ш ш O O 43rd Ave 140 ш O $\mathbf{\omega}$ 51st Ave LEVEL-OF-SERVICE LEGEND: 139 **EASTBOUND** F(80) F(70) F(70) F(60) O $\mathbf{\omega}$ 59th Ave 138 F(50) F(50) ш ш O O 67th Ave 137 O ш $\mathbf{\omega}$ \mathbf{m} 75th Ave 136 $\mathbf{\omega}$ $\mathbf{\omega}$ $\mathbf{\omega}$ 83rd Āve 135 135 91st Ave O O m ⋖ ⋖ $\mathbf{\omega}$ 134 134 101 5:00 p.m. 6:30 p.m. 3:30 p.m. 4:00 p.m. 6:00 p.m. 3:30 p.m. 6:00 p.m. 4:00 p.m. 5:00 p.m. 6:30 p.m.

51

I-10 (Between Loop 202 / SR 51 & Pinal County Line) Evening - Fall 2001

During the peak period, westbound congestion was found on Broadway Rd approaching the signal at the I-10 southbound entrance ramp; when congested, approximately 20 to 40 vehicles were queued in the left lane at the signal.

During the peak period, eastbound (southbound) congestion was found on I-10 between I-17 and Southern Ave; average estimated speeds typically ranged from 30 to 50 mph. Contributing factors to the congestion were 1) the lane drop (5 lanes to 4) at University Dr and 2) vehicles merging into the two right lanes to exit at US 60.

51 143 10 202 Van Buren St **Broadway** 48th St Buckeye Rd Rd 40th 143 Southern Ave 10 24th St 48th University Dr During the peak period, Southern Ave

Baseline Rd

Guadalupe

Rd

Elliot

Rd

Warner.

Rd

56th St

Queen

Creek

Rd

Ray Rd

During the peak period, eastbound Unit congestion was found on US Rte 60 from the vicinity of I-10 to McClintock Dr (approx. 3 miles east of I-10); average estimated speeds along this segment typically ranged from approximately 10 to 30 mph. Ongoing construction between I-10 and McClintock Dr may have exacerbated the congestion (right shoulder closed). The queue typically extended back onto the I-10 southbound exit ramp (thru-traffic on I-10 was not affected).

During the peak period, congestion was found on the southbound entrance ramp at Baseline Rd; when congested, approximately 25 to 35 vehicles per lane were queued at the ramp meter (two thrulanes at ramp meter).

After 5:00 p.m., congestion was found on the southbound exit ramp at Chandler Blvd; when congested, queue populations ranged widely, from approximately 20 to 45 vehicles per lane (two right-turn lanes). At its maximum observed extent, the queue extended back into the right lane of I-10 to the vicinity of Ray Rd (a distance of approximately one mile).

Intermittently, eastbound congestion was found on Chandler Blvd approaching the signal at I-10; when congested, queue populations typically ranged from 20 to 30 vehicles per lane (three lanes).

FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

During the peak period, congestion was found on the southbound entrance ramp at Broadway Rd; when congested, approximately 20 to 25 vehicles per lane were queued at the ramp meter (two thru-lanes at ramp meter).

60

Chandler

Blvd.

Riggs Rd

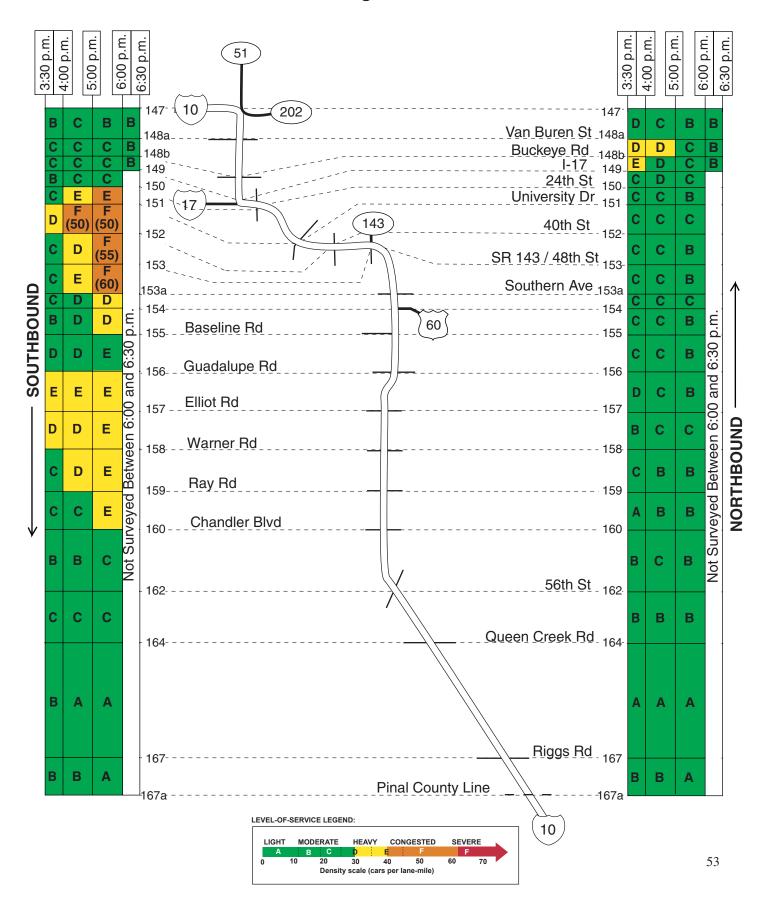
congestion was found on the southbound entrance ramp at SR 143 / 48th St; when congested, queue populations on the ramp typically ranged from approximately 60 to 80 vehicles per lane. Contributing factors to the congestion were 1) the physical characteristics of the exit ramp (sharp turn) at SR 143 and 2) the merge into congested southbound flow on I-10.

On one day only, congestion was found on the northbound exit ramp at Ray Rd; approximately 20 to 25 vehicles were queued at the signal at the head of the ramp (left-turn lane only).

Intermittently, westbound congestion was found on Chandler Blvd approaching the signal at I-10; when congested, queue populations typically ranged from 20 to 25 vehicles per lane (two thru-lanes).

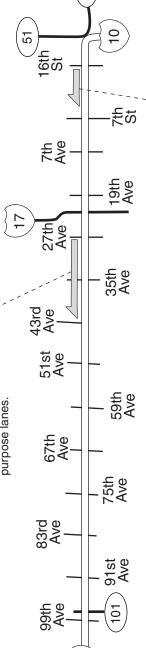
Pinal County line

I-10 (Between SR 202 / SR 51 & Chandler Blvd) Evening - Fall 2001



I-10 HOV (Between 99th Ave & Loop 202 / SR 51) Evening - Fall 2001

During the peak period, westbound congestion was found in the I-10 HOV lane between 19th Ave and 51st Ave; average estimated speeds along this segment typically ranged from 30 to 50 mph. Contributing factors to the congestion may have been 1) sun glare and 2) friction between the HOV lane and congested general-purpose lanes.



202

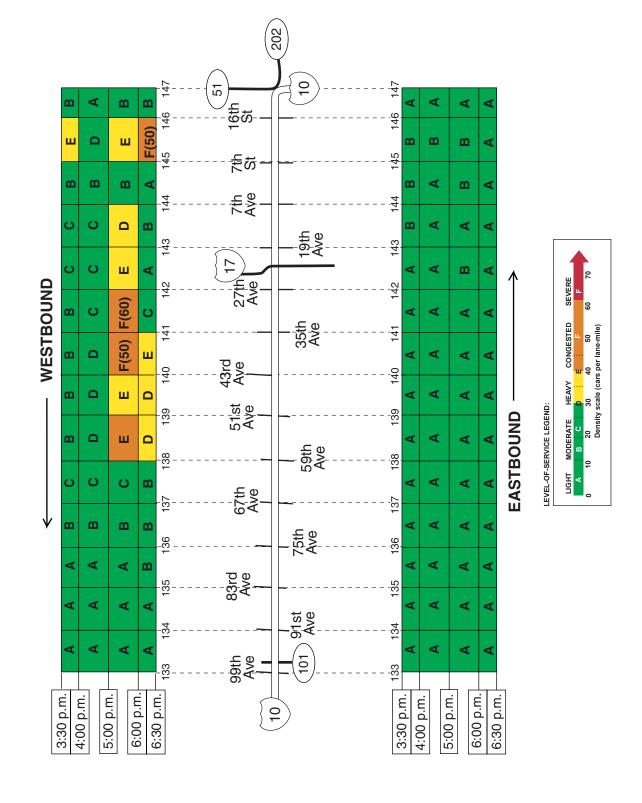
On some days but not others, westbound congestion was found in the I-10 HOV lane between 16th St and 7th St; average estimated speeds along this segment typically ranged from 40 to 50 mph. Contributing factors to the congestion may have been 1) sun glare and 2) friction between the HOV lane and congested general-purpose lanes.

FREEWAY TRAFFIC QUALITY

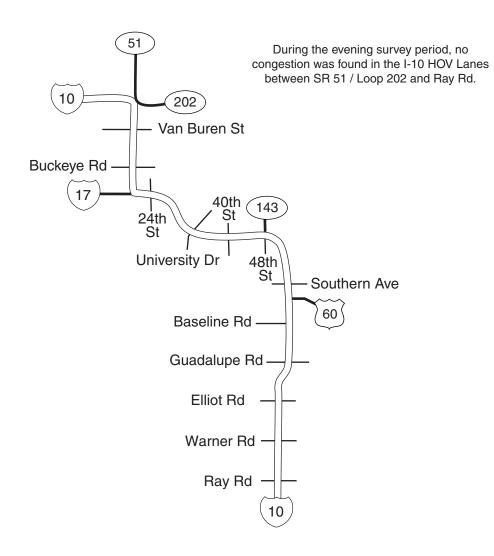
Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

I-10 HOV (Between 99th Ave & Loop 202 / SR 51) Evening - Fall 2001



I-10 HOV (Between Loop 202 / SR 51 & Ray Rd) Evening - Fall 2001

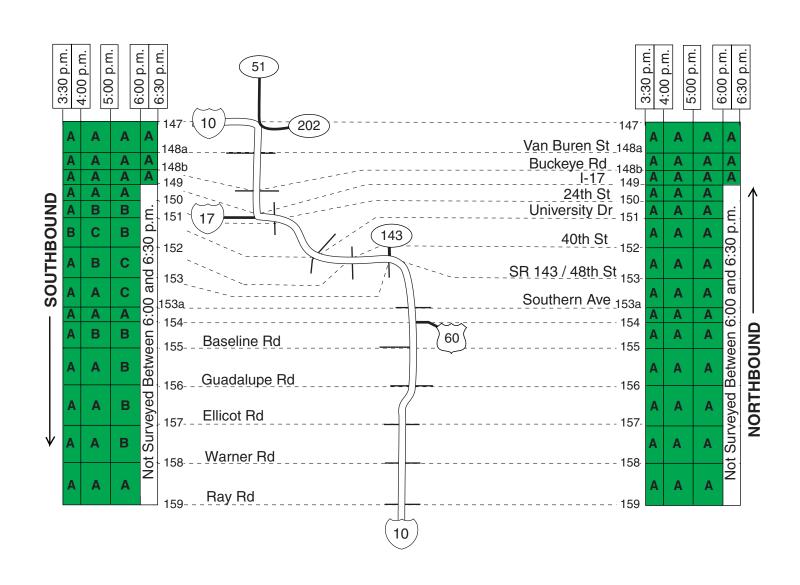


FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

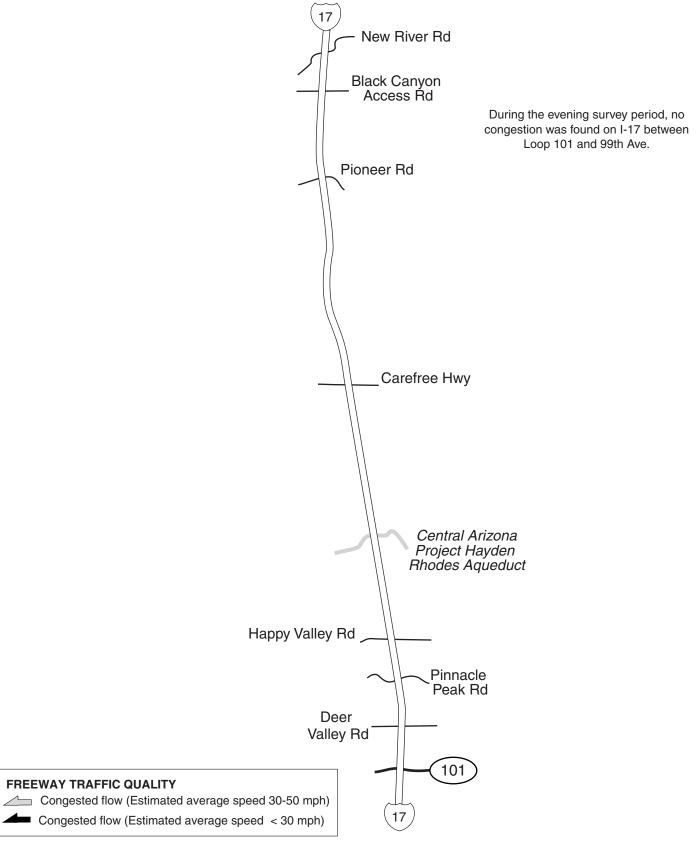
Congested flow (Estimated average speed < 30 mph)

I-10 HOV (Between SR 202 / SR 51 & Pinal County Line) Evening - Fall 2001



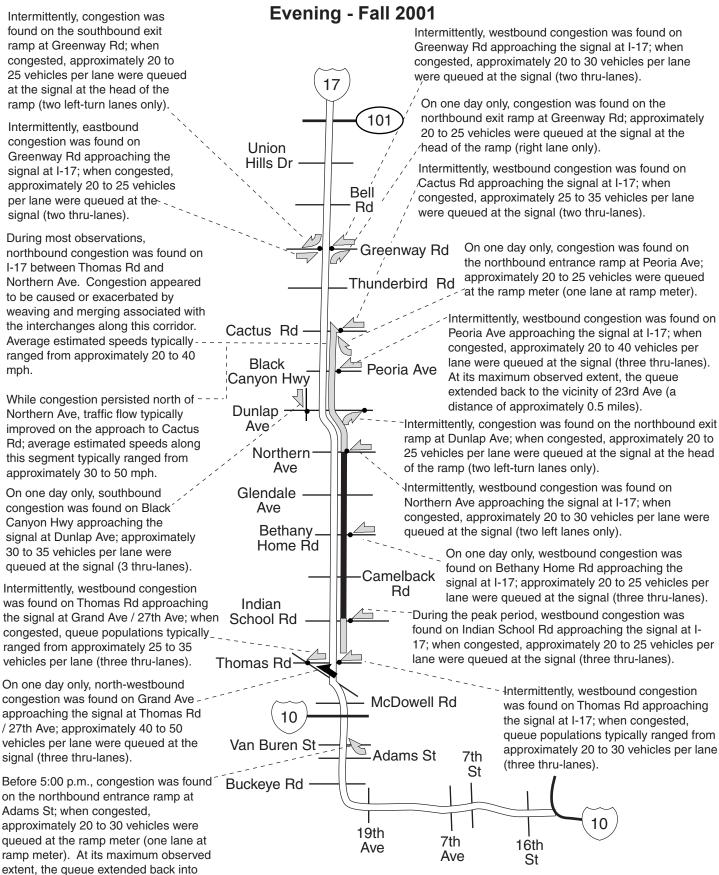


I-17 (Between 99th Ave & Loop 101) Evening - Fall 2001



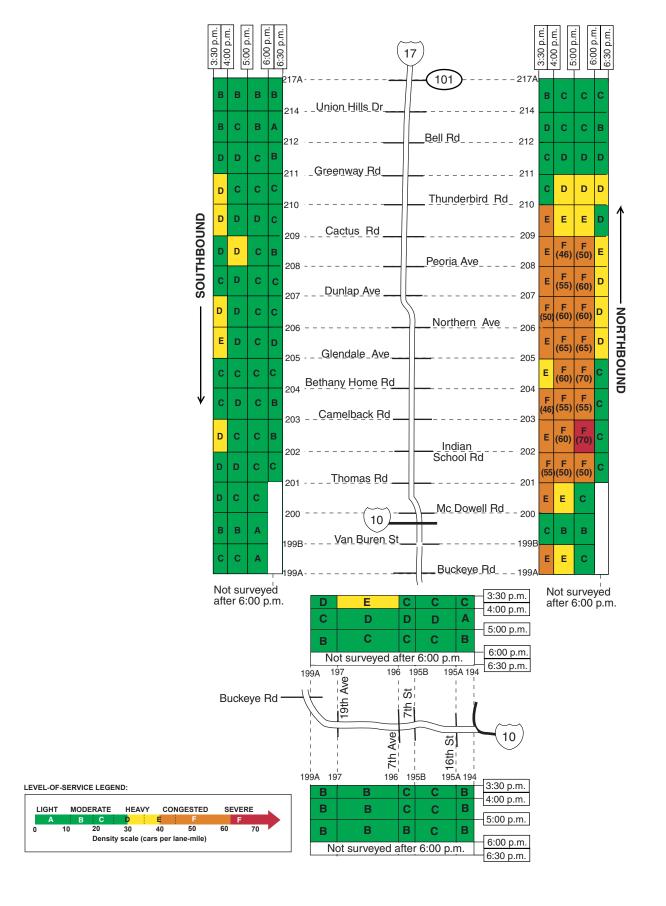
I-17 (Between 99th Ave & Loop 101) **Evening - Fall 2001** 6:00 p.m. 5:00 p.m. 6:30 p.m. 6:00 p.m. 3:30 p.m. 4:00 p.m. 3:30 p.m. 5:00 p.m. 4:00 p.m. 6:30 p.m. 17 New River Rd A Black Canyon Access Rd 229 229 Α A Α Α Pioneer Rd 225 Not Surveyed After 6:00 p.m. В В В В Not Surveyed After 6:00 p.m. SOUTHBOUND Carefree Hwy 223 NORTHBOUND В В В В Central Arizona Project Hayden Rhodes Aqueduct Happy Valley Rd 218 В В В В Pinnacle Peak Rd C В C C В C В В Deer 217B-⁻217B Valley Rd В C В C В 101 217A -217A

I-17 (Between Loop 101 & I-10) Evening - Fall 2001

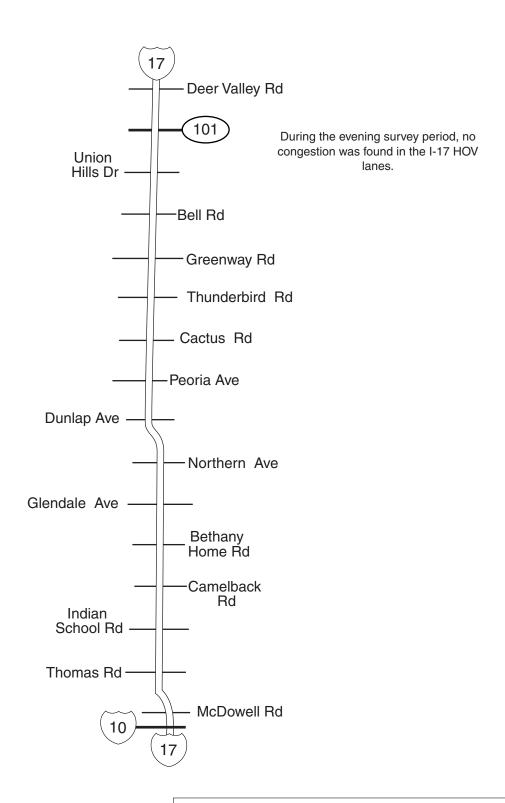


the right lane of Adams St.

I-17 (Between Loop 101 & I-10) Evening - Fall 2001



I-17 HOV Evening - Fall 2001

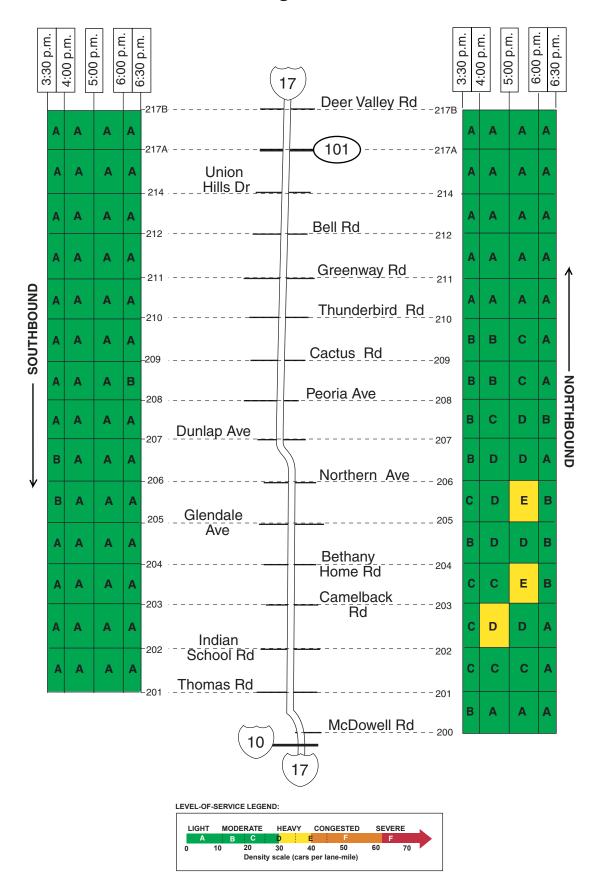


FREEWAY TRAFFIC QUALITY

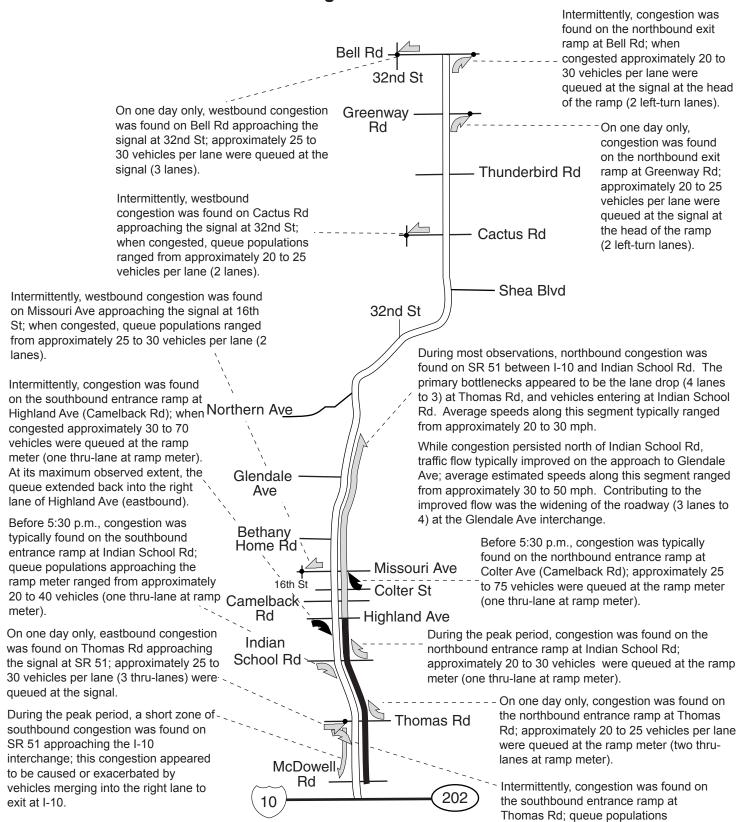
Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

I-17 HOV (Between Deer Valley Rd & McDowell Rd) Evening - Fall 2001

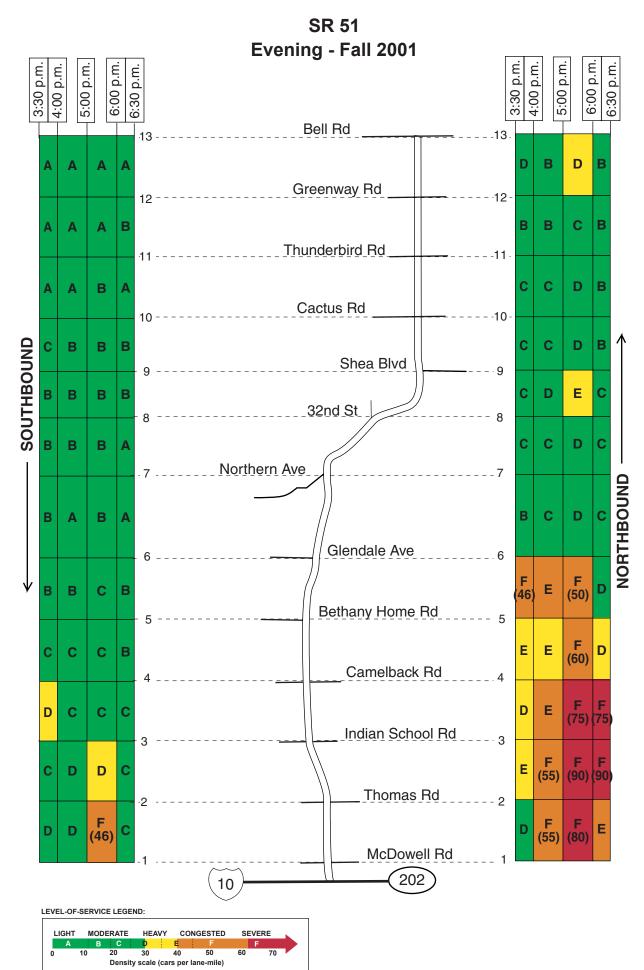


SR 51 Evening - Fall 2001



approaching the ramp meter ranged from approximately 20 to 25 vehicles per lane

(two thru-lanes at ramp meter).



US ROUTE 60 (Between I-10 & Higley Rd) Evening - Fall 2001

During most observations, congestion was found on the eastbound entrance observed extent, the queue extended approximately 20 to 40 vehicles (one lane at ramp meter). At its maximum queue populations approaching the ramp at Mesa Dr; when congested, ramp meter typically ranged from northbound congestion was found congested, approximately 25 to 30 vehicles were queued in the left lane at the signal (left-turn on Mesa Dr approaching the signal at US Rte 60; when During the peak period, lane only).

During most observations, congestion was found on the eastbound entrance amp at Mesa Dr; when congested, are populations approaching the peak period, was found on the eastbound entrance the westbound entrance the westbound entrance amp at Gilbert Rd; when congested, queue approaching the ramp meter typically and at ramp meter).

During the peak period, congestion was found on the westbound entrance ramp at Gilbert Rd; when congested, queue populations approaching the ramp metery.

berrod,

During the peak period, eastbound congestion was ound on trance

Itance

Country Club Dr. Ongoing construction between td; when exacerbated the congestion (right shoulder caching closed). Average speeds along this segment typically typically ranged from approximately 15 to 25 mph.

While congestion persisted east of Country Club Dr, traffic flow typically improved on the approach - to Lindsey Rd; average estimated speeds along this corridor typically ranged from approximately 35 to 45 mph.

Greenfield Vista Dr Lindsay Country Club Dr Alma School Dobson McClintock ے Rural

During most observations, congestion was found on the eastbound entrance ramp at Country Club Dr; when congested, queue populations approaching the ramp meter typically ranged from approximately 20 to 40 vehicles (one lane at ramp meter). At its maximum observed extent, the queue extended back onto the right

construction between I-10 and McClintock

approximately 10 to 30 mph. Ongoing

the vicinity of I-10 to McClintock Dr; average estimated speeds along this

segment typically ranged from

Dr may have exacerbated the congestion

right shoulder closed).

congestion was found on US Rte 60 from

During the peak period, eastbound

CONSTRUCTIONIZONE

Intermittently, northbound congestion was found on Gilbert Rd approaching the signal at US Rte 60; when congested, approximately 20 to 25 vehicles were queued in the left lane at the signal.

CONSTRUCTION ZONE

During the peak period, congestion was found on the eastbound entrance ramp at Val Vista Dr; when congested, queue populations approaching the ramp meter typically ranged from approximately 20 to 25 vehicles (one lane at ramp

meter).

FREEWAY TRAFFIC QUALITY

ane of Country Club Dr.

☐ Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

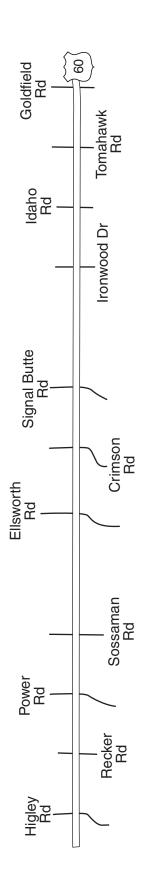
99 186 186 Higley Rd * Interpolated SEVERE Greenfield Rd O ပ O O ۵ 185 185 LIGHT MODERATE HEAVY CONGESTED 20 30 40 50 Density scale (cars per lane-mile) y val Vista Dr Ö ۵ 184 184 Lindsay Rd _{Vi} ш ш LEVEL-OF-SERVICE LEGEND: 183 183 Gilbert | Rd F (55) ш O 9 182 182 F (55) CONSTRUCTION ZONE ш ш ш Stapley Dr 181 <u>18</u> WESTBOUND F (60) F (46) Mesa |Dr ш Evening - Fall 2001 .08 180 F (46) F (60) ш Q Country Club Dr 179 F (100) F (80) O ۵ Alma Schopi Rd 178 178 **EASTBOUND** F (85) F (100) O ш Ö Dobson Rd 177 177 ш $\mathbf{\omega}$ O ш O 101 176 McClintock Dr O ပ O m CONSTRUCTION ZONE 175 175 F (55) F (70) F (55) F (60) F (45) F(60) F(60) F(60) O O 174 Rural Rd F (75) Ω ۵ Mill Ave 173 F (85) F (105) ۵ Ω Priest Dr 171 172 17,1 172 ш മ ပ Ω m 9 5:00 p.m. 4:00 p.m. 5:00 p.m. 6:00 p.m. 6:30 p.m. 3:30 p.m. 4:00 p.m. 6:00 p.m. 6:30 p.m. 3:30 p.m.

(Between I-10 & Higley Rd)

US Route 60

US ROUTE 60 (Between Higley Rd & Goldfield Rd) Evening - Fall 2001

During the evening survey period, no congestion was found on US Rte 60 between Higley Rd and Goldfield Rd.

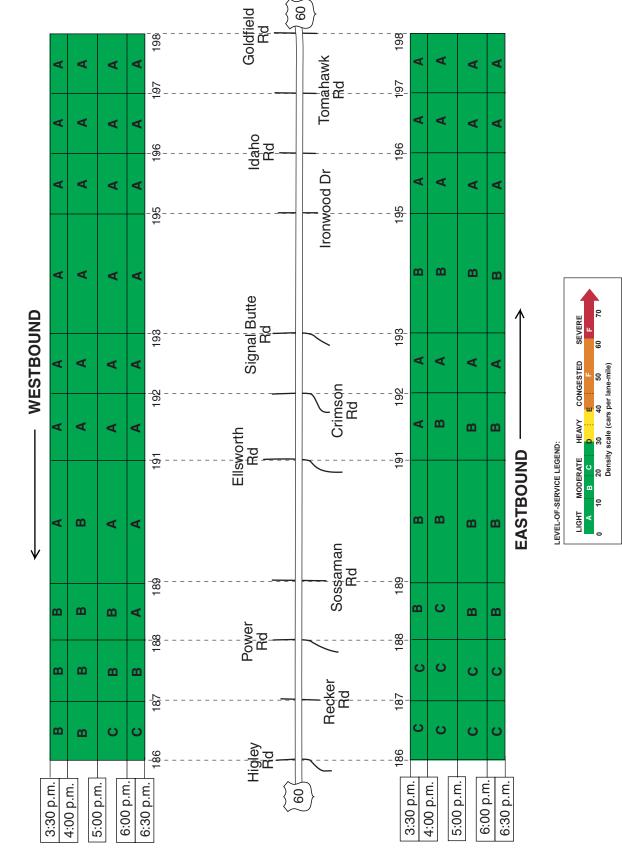


FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

US Route 60 (Between Higley Rd & Goldfield Rd) Evening - Fall 2001



LOOP 101 - Agua Fria Freeway (Between I-10 & I-17) Evening - Fall 2001

59th

Ave

Intermittently, congestion was found on the southbound exit ramp at Union Hills Dr; when congested, approximately 20 to 30 vehicles per lane were queued at the signal at the head of the ramp (2 right lanes).

During most observations, westbound congestion was found on Union Hills Dr approaching the signal at 83rd Ave; when congested, queue populations typically ranged from approximately 20 to 30 vehicles per lane (left lane only). At its maximum observed extent, the queue extended back to the vicinity of the signal at Loop 101.

Thunderbird Rd

Union
Rd

On one day only, southbound congestion was found on 67th
Ave approaching the signal at
Loop 101; approximately 20 to
25 vehicles were queued at the signal (left lane only).

67th

Ave

75th

Ave

Intermittently, congestion was found on the northbound exit ramp at Union Hills Dr; when congested, approximately 25 to 45 vehicles per lane were queued at the signal at the head of the ramp (2 left-turn lanes).

During most observations, westbound congestion was typically found on Loop 101 (Agua Fria Fwy) between I-17 and 51st Ave; average estimated speeds typically ranged from approximately 30 to 50 mph. Congestion appeared to be caused or exacerbated by weaving and merging associated with the interchanges along this corridor.

27th

Ave

43rd

Ave

51st

35th

Ave

Peoria Ave
Olive Ave
Northern Ave
Glendale Ave

101
Camelback Rd
— Indian School Rd
— Thomas Rd
— McDowell Rd

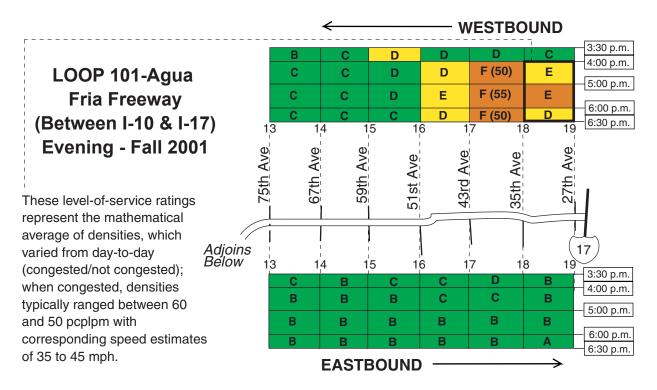
Grand Ave

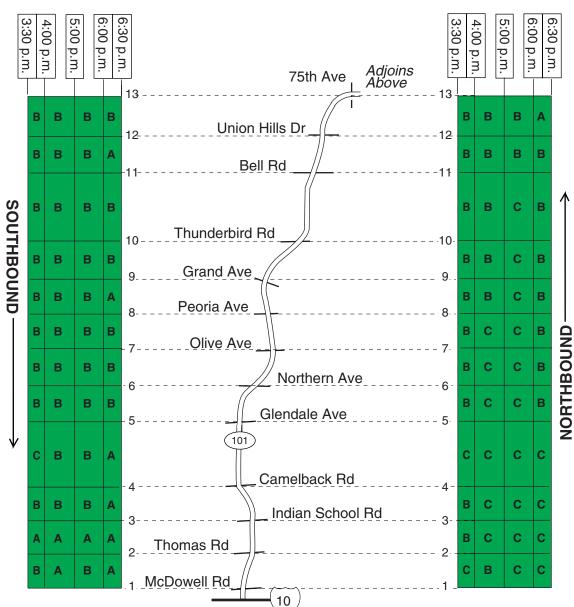
FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

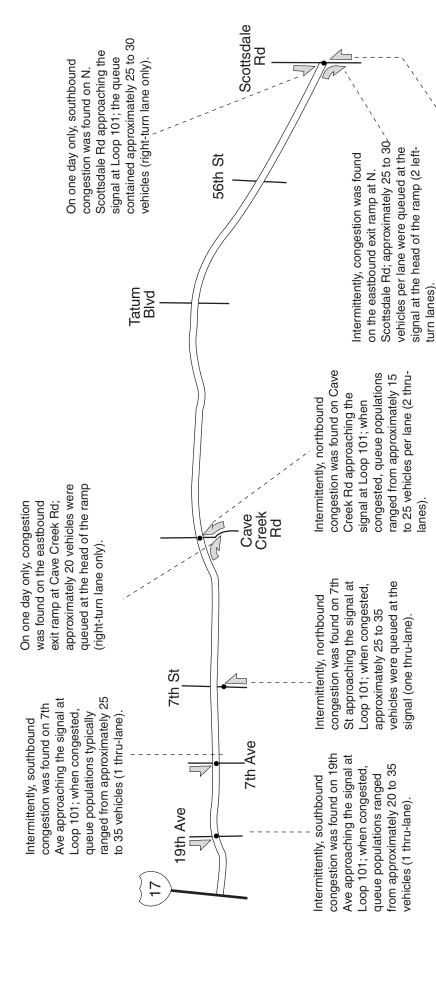
Congested flow (Estimated average speed < 30 mph)

10





Loop 101 - Pima Freeway (Between I-17 & Scottsdale Rd) Evening - Fall 2001



FREEWAY TRAFFIC QUALITY

Scottsdale Rd approaching the signal at Loop 101; when

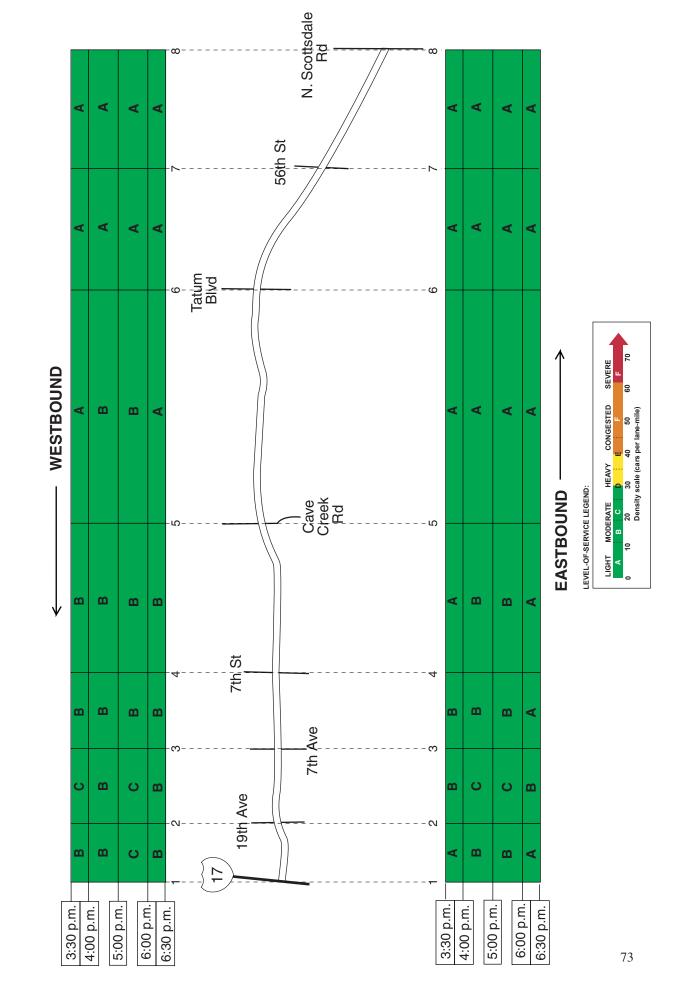
congested, queue populations ranged from approximately 25 to 30 vehicles per lane (2 left-turn

ntermittently, northbound congestion was found on N.

Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed 30 mph)

Loop 101-Pima Freeway (Between I-17 & N. Scottsdale Rd) Evening - Fall 2001



Loop 101 - Pima Freeway (Between Princess Dr & McDowell Rd) Evening - Fall 2001

Raintree Dr -

Intermittently, congestion was found at the Loop 101 terminus at Princess Dr; when congested, approximately 25 to 35 vehicles per lane were queued in the right-turn lanes at the head of the ramp (two right-turn lanes).

Princess Dr

Bell Rd

Bell Rd

Frank Lloyd
Wright Blvd

Printage

Rd

Intermittently, eastbound congestion was found on Princess Dr approaching the signal at Pima Rd; when congested, the queue typically extended back to the signal at Loop 101 (a distance of approximately 1/2 mile).

During most observations, northbound congestion was found on the frontage road approaching the signal at Frank Lloyd Wright

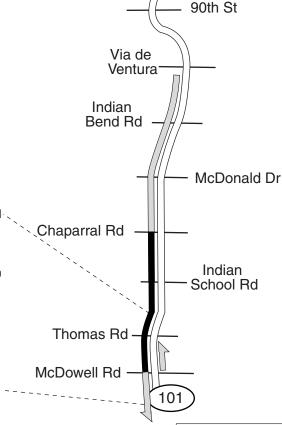
Cactus Rd

Shea Blvd

During most observations, northbound congestion was found on the frontage road approaching the signal at Frank Lloyd Wright Blvd; when congested, approximately 25 to 35 vehicles per lane were queued at the signal (two left-turn lanes).

During the peak period, southbound congestion was found on Loop 101 between Via de Ventura and McDowell Rd. Congestion appeared to be caused or exacerbated by weaving and merging associated with the interchanges along this corridor. Average speeds ranged widely, from approximately 15 to 45 mph.

While congestion persisted south of McDowell Rd, traffic flow typically improved on the approach to McKellips Rd (onemile south of Mckellips Rd); average estimated speeds along this segment ranged from approximately 35 to 50 mph. Contributing to the improved flow was the widening of the roadway (3 lanes to 4) at McKellips Rd.

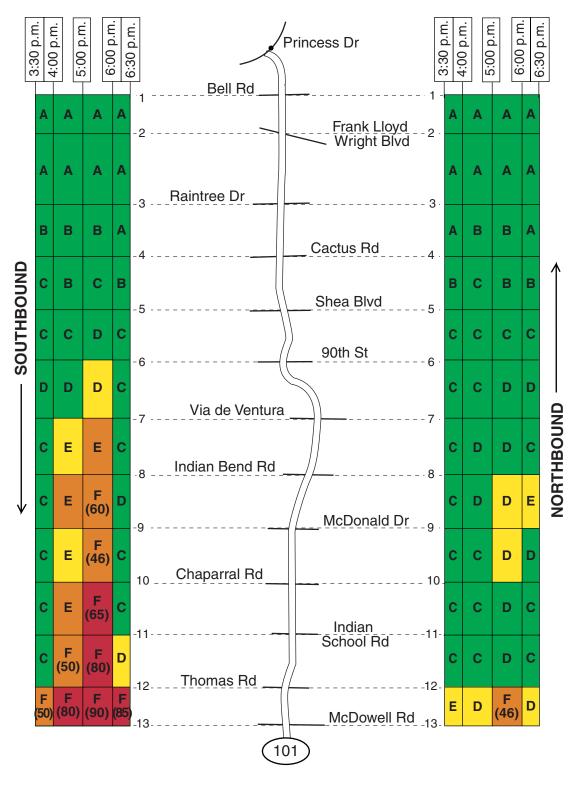


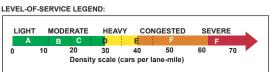
FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

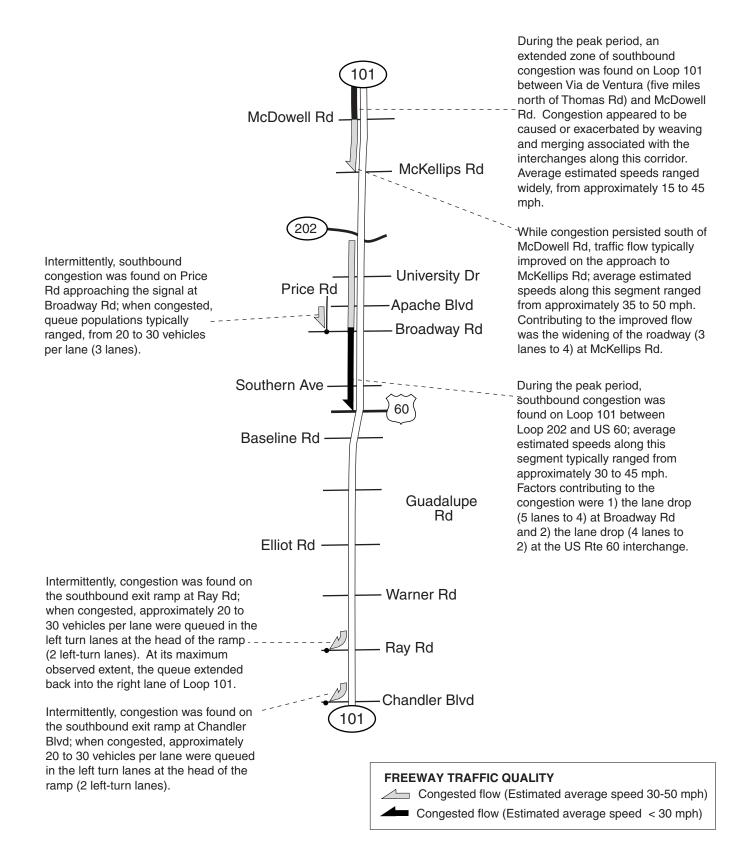
■ Congested flow (Estimated average speed < 30 mph)

Loop 101-Pima Freeway (Between Princess Dr & McDowell Rd) Evening - Fall 2001

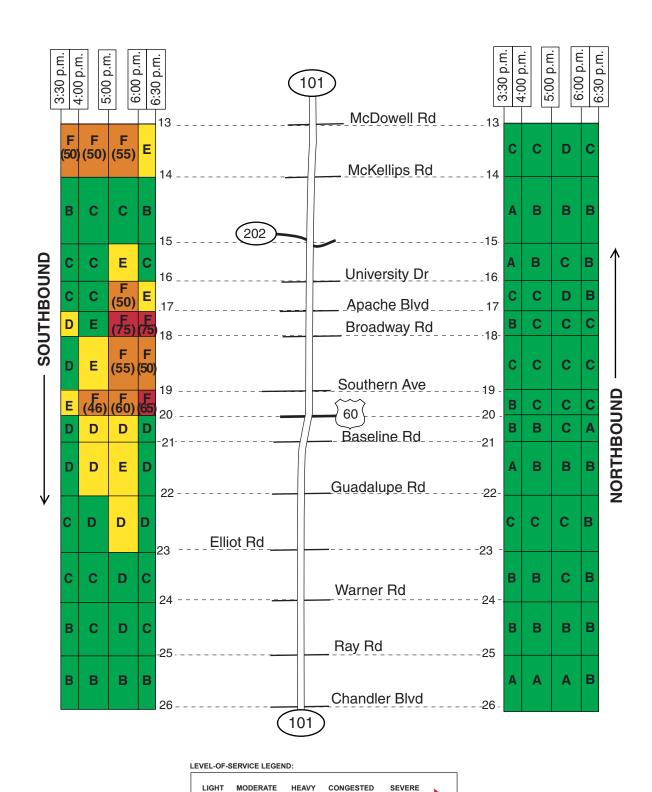




Loop 101 - Pima Freeway (Between McDowell Rd & Chandler Blvd) Evening - Fall 2001



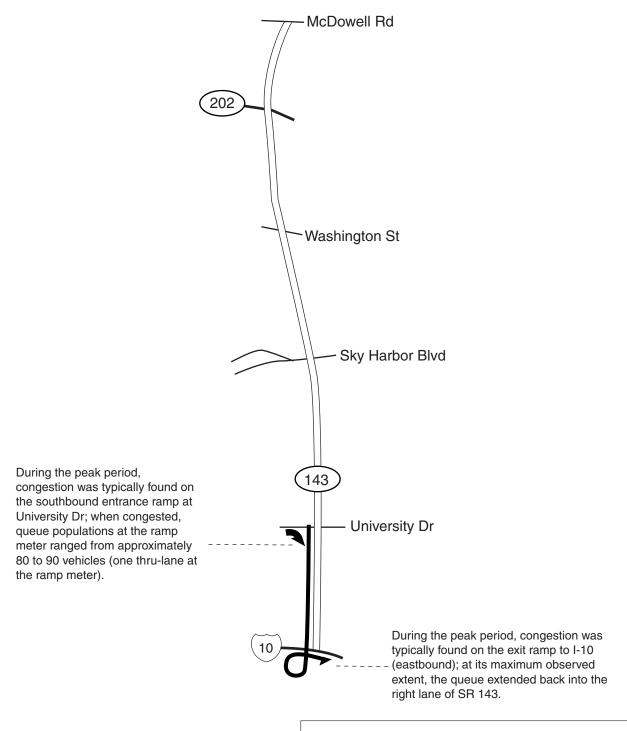
Loop 101 Pima Freeway (Between McDowell Rd & Chandler Blvd) Evening - Fall 2001



20 30

Density scale (cars per lane-mile)

Rte 143 Evening - Fall 2001

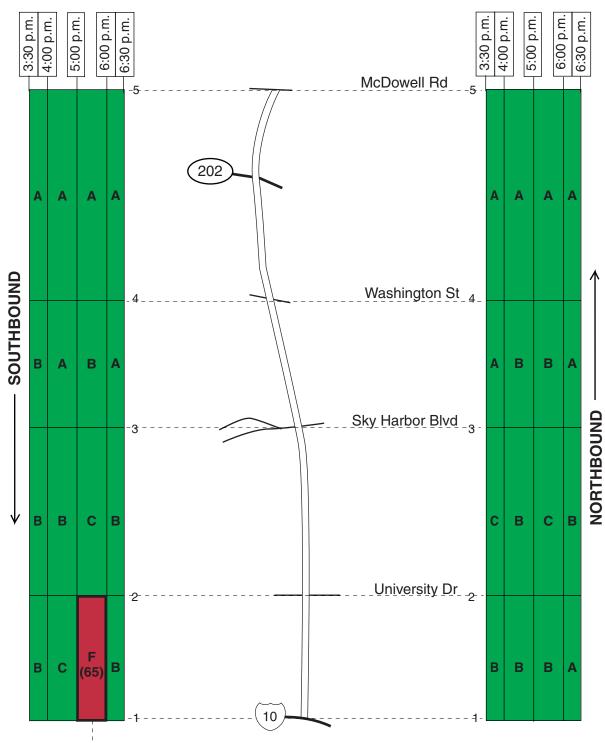


FREEWAY TRAFFIC QUALITY

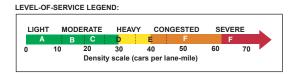
Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)

SR 143 Evening - Fall 2001



These level-of-service ratings represent the mathematical average of densities, which varied widely between the right- and left-hand lanes. When congested, densities in the right lane approaching I-10 were as high as 80 pcplpm with corresponding speed estimates of 20 to 25 mph.



Evening - Fall 2001 Loop 202

During most observations, westbound congestion was typically found on Loop 202 between 32nd St and I-10 SR 51; average estimated speeds typically ranged from approximately 25 to 50 mph. This congestion appeared to be caused or exacerbated by the lane drop (3 lanes to 2) at I-10 / SR 51.

approximately 30 to 40 vehicles per lane were found on Country Club Drive approaching the Intermittently, southbound congestion was signal at McKellips Rd; when congested, queued at the signal (4 lanes). Country Club Dr

McKellips Rd

Dobson Rd 101 McClintock Dr Scottsdale Rd Mill Ave - Van Buren St Priest Dr St appeared to cause or exacerbate and 24th St; traffic entering at 24th During the peak period, eastbound on Loop 202 between I-10 / SR 51 congestion was typically found on 40th St eastbound congestion was found On one day only, a short zone of 32nd St

Š

51

During the peak period, average estimated speeds along this McClintock Dr, the congestion extended across all four lanes. During most observations, eastbound congestion was found segment typically ranged from approximately 20 to 30 mph. vehicles merging into the two right lanes to exit at Loop 101 appeared to cause or exacerbate the congestion. West of on Loop 202 between SR 143 and Loop 101 (Pima Fwy);

vehicles per lane were queued at the signal (3 the queue extended back through the signal at thru-lanes). At its maximum observed extent, Loop 202, and onto the Loop 202 exit ramp. approaching the signal at Country Club Dr; when congested, approximately 50 to 75 congestion was found on McKellips Rd' During most observations, eastbound

Alma School

FREEWAY TRAFFIC QUALITY

202; this congestion appeared to be the freeway ramp from I-10 to Loop

the congestion.

caused or exacerbated by weaving

east of the SR 51/Loop 202/ I-10

Interchange.

Congested flow (Estimated average speed 30-50 mph)

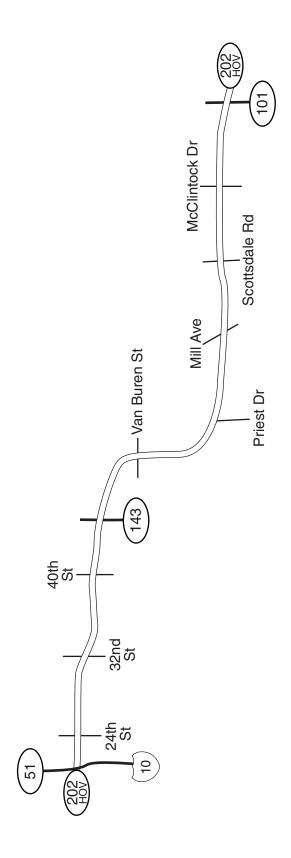
■ Congested flow (Estimated average speed < 30 mph)

McKellips Rd _____ 4 $\mathbf{\omega}$ $\mathbf{\omega}$ densities, which varied widely between the right- and left-hand lanes. When congested, densities in the right lane approaching I-10 were as high as 100 Alma School Ro These level-of-service ratings represent the mathematical average of and 70 pcplpm with corresponding speed estimates of 15 to 25 mph. O O \mathbf{m} 9 Dobson Rd 9 $\mathbf{\omega}$ O O മ 4 $\mathbf{\omega}$ ⋖ Loop 101 101 m \mathbf{m} $\mathbf{\omega}$ $\mathbf{\omega}$ McClintock Dr F (70) F (70) F (55) \mathbf{m} $\mathbf{\omega}$ $\mathbf{\omega}$ Scottsdale Rd Evening - Fall 2001 WESTBOUND F (65) F (50) F (50) F (55) O O $\mathbf{\omega}$ Mill Ave F (65) F (75) F (50) F (50) \mathbf{m} \mathbf{m} $\mathbf{\omega}$ 56th St **EASTBOUND** F (65) \mathbf{m} ပ O Van Buren St O Ш O $\mathbf{\omega}$ 20 SEVERE 143 Ш O CONGESTED 20 30 40 Density scale (cars per lane-mile) 40th St 2A -Ζ HEAVY ш O \mathbf{m} LEVEL-OF-SERVICE LEGEND: 32nd St MODERATE B C F (60) 10 Ш ш Ш ш LIGHT 24th St 10 5:00 p.m. 6:00 p.m. 51 5:00 p.m. 3:30 p.m. 4:00 p.m. 6:30 p.m. 3:30 p.m. 6:00 p.m. 4:00 p.m. 6:30 p.m. 81

Loop 202

Evening - Fall 2001 Rte 202 HOV

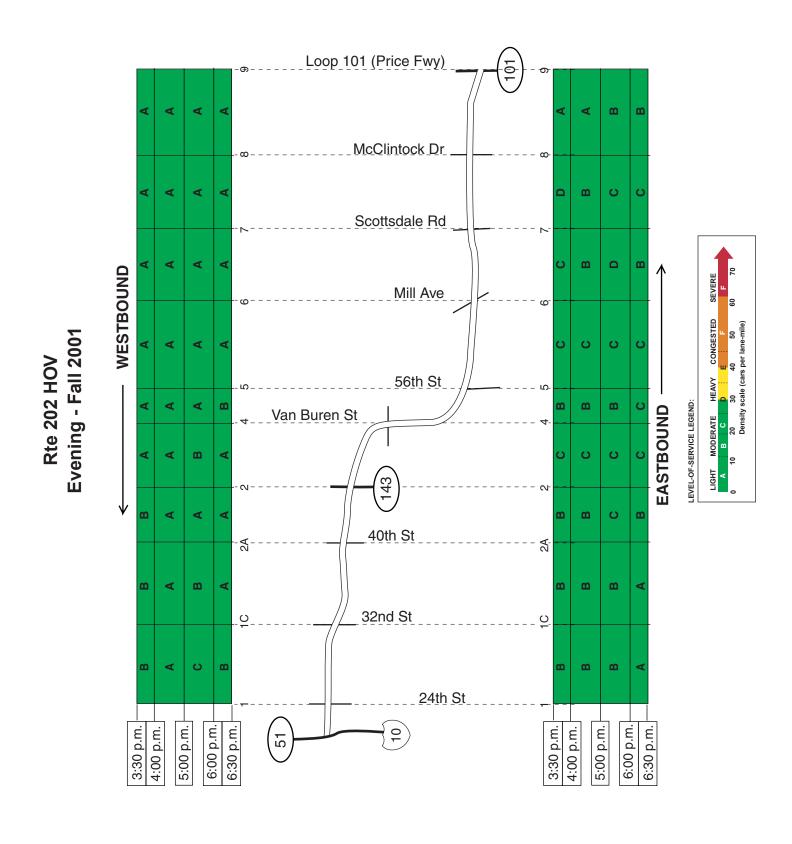
During the evening survey period, no congestion was found in the Loop 202 HOV lanes.



FREEWAY TRAFFIC QUALITY

Congested flow (Estimated average speed 30-50 mph)

Congested flow (Estimated average speed < 30 mph)</p>



APPENDIX A

METHODOLOGY DESCRIPTION

Procedures for determining freeway level-of-service

PERFORMANCE MEASURE: DENSITY-BASED LEVEL OF SERVICE

According to the 2000 Update to the Highway Capacity Manual (the HCM), the defining parameter of freeway level-of-service is density, measured in units of passenger-cars per lane per mile (pcplpm). While densities are commonly calculated from speed and volume data, another method is to measure densities directly from aerial photographs. This is the approach used in the Phoenix survey program.

The LOS rating system uses the letters "A" through "F" to describe traffic quality: LOS "A" represents superior traffic quality (very light traffic), while LOS "F" represents poor traffic quality (congested flow involving various degrees of delay). These letters are assigned based on how densely cars are traveling on the road. Research has shown that for all densities below 40 pcplpm, vehicles generally move at or close to normal highway speed; LOS "A" through "E" represent these densities according to the following table (pcplpm):

LOS "A": densities from zero to 11 (very light traffic);

LOS "B": densities from 12 to 18 (light to moderate traffic);

LOS "C": densities from 19 to 26 (moderate traffic);

LOS "D": densities from 27 to 35 (moderate to heavy traffic);

LOS "E": densities from 36 to 45 (heavy traffic, but still at speeds close to free-flow)

At densities greater than **40**, speeds typically decrease and traveler delays are incurred. Because flow at all densities greater than **46** are regarded as LOS "F", this report attaches actual densities to all LOS "F" ratings. Accordingly:

LOS "F":

- Densities from **46 to 60** indicate delay involving minor degrees of slowing; average speeds usually range between 50 and 30 mph;
- Densities from **60 to 80** indicate traffic flow at average speeds usually ranging between 30 and 20 mph; some stopping is possible
- Densities from **80 to 100** indicate congested stop-and-go traffic flow, with some stopping possible; average speeds usually range between 20 and 10 mph;
- Densities above 100 indicate severe congestion, with considerable stop-and-go flow likely. For reference, densities above 110 usually indicate the presence of unusual events (accidents, roadwork, etc.). The practical maximum value for density measurements is 180; the theoretical maximum value is 264 (at 20 feet per vehicle). Again, daily recurring congestion rarely will measure densities above 100.

DATA REDUCTION PROCEDURES

From overlapping time-stamped photographs, densities by highway segment were determined by manual counts taken along the entire segment length. Vehicles were classified as cars, trucks, buses, or tractor-trailers when counted; later, passenger-car equivalents (pce's) were derived according to the following table:

Vehicle type:	PCE's:
cars	1
trucks	1.5
tractor-trailers	2.0
buses	1.5

Data that were atypical due to roadwork or to known or suspected incidents were coded for exclusion from the averaging process. All data were then entered into a database program, that performed the following tasks: 1) samples were grouped by 30 minute time slice; 2) average densities were calculated; and 3) densities were converted into service levels "A" through "F". The computer then prepared matrices showing each averaged service level rating plotted by time and highway segment. These data matrices were then copied into the traffic quality tables that are provided in this report.

In the tables, all LOS F conditions (congested traffic flow) have been outlined and shaded; this permits quick identification of locations experiencing demand at levels exceeding capacity. Because LOS "F" encompasses a wide range of densities, the actual density values are entered next to the "F"; using the travel characteristics in the density ranges provided above, the nature of the flow in LOS F segments can be determined.

While examining the photography, data technicians also identified side streets and on/off ramps that were congested. Where these problems were recurring, descriptive narratives were prepared. These narratives, together with other observations, are provided on "narrative" maps set opposite each traffic quality table.

APPENDIX B

METHODOLOGY DESCRIPTION

Procedures for obtaining speed/density samples for calibration of the Van Aerde Speed / Density Model

BACKGROUND

In the spring of 1995, Skycomp collected data to compare the speed of vehicles through congested freeway zones with corresponding densities obtained from aerial photographs. The purpose was to explore the relationship between the two, and, given a reasonable correlation, to prepare a model by which vehicle speeds could be estimated from aerial density photographs.

The program was conceived and executed by the Metropolitan Washington (D.C.) Council of Governments (MWCOG). Aerial data were collected by Skycomp; analysis of the data and calibration of the Van Aerde speed/density model were conducted by MWCOG (draft paper included in this appendix).

A secondary objective was to evaluate the accuracy of aerial speed and density measurements by comparing them to data collected by traditional methods (floating cars and loop detectors embedded in the pavement).

Accordingly, segments of freeway were chosen to be surveyed that: 1) were expected to generate congested traffic flow; and 2) either contained a loop detector station or would accommodate quick turnarounds for multiple floating car runs. Thus, while data were being collected in the air (290 speed samples were obtained from the air, along with corresponding densities), loop detector or floating car data were collected concurrently on the ground.

The outcome of this study was a finding that travel speeds across congested freeway segments could be determined with reasonable accuracy using only aerial density photographs. It was also found that speeds and densities obtained through aerial techniques closely matched data obtained using the traditional ground methods.

PROCEDURES TO OBTAIN SPEED / DENSITY SAMPLES:

The observer/photographer followed the following procedure to obtain all speed/density samples: he first flew along the selected survey segment while taking time-stamped overlapping density photographs of the entire segment; next, at the upstream end, he selected a target "floating" car for tracking; he photographed the target as it entered and departed the segment, while simultaneously timing its run to the nearest second. He then took an "after" density photo set; and then recorded the following information on a clipboard: the time of the sample, the target vehicle description, lane(s) traveled, elapsed time, and any special notes. This procedure was repeated for each speed/density data point.

In the actual course of sampling, this procedure was modified in several ways. First, where cars were moving at high (free-flow) speeds, the density did not change significantly between samples; thus sometimes three or more floating cars were timed between density runs.

Another modification done in-flight is as follows: the observer noted in several cases that the density set taken before the target vehicle went through better reflected the conditions the car encountered than the density set taken after the vehicle went through (or vice versa). This was usually due to a delay in changing film, extra maneuvering the airplane, or any other event which delayed the "after" density sample for several minutes after the completion of the run. While normally the density associated with each speed sample was an average of the "before" and "after" density sets, in these cases only the "before" or "after" density set would be used (as directed by the observer).

With regard to selection of target vehicles, the plan was to select cars that reflected the average speed of traffic, just as floating car drivers are instructed to approximate the speed of traffic flow. Fortunately, vehicles have little freedom to choose their speeds in the congested density ranges (above 40 pcplpm). So, for example, almost any vehicle in a congested traffic stream in the middle lane of three will give a suitable floating car measurement. Even tractor-trailers (unless heavily loaded and traveling uphill) moved at the same speed as passenger cars. Thus the criteria the observer used in selecting each target vehicle was 1) is it in the correct lane; and 2) does the vehicle stand out so that it is easy to keep track of?

Also, in the event that the highway had four travel lanes in one direction, alternating samples were taken from both middle lanes.

In the event that a driver switched lanes while being tracked, the observer noted the lane change and also noted which lane the car spent the majority of time in (this is the lane for which a density count would be made later). In several cases (infrequently), the observer abandoned tracking certain vehicles when: 1) the driver made multiple lane changes, trying to beat the average speed of traffic; 2) the driver switched lanes and changed speeds obviously and significantly; 3) the vehicle turned out to be a heavily loaded truck which delayed the traffic stream; or 4) the observer "lost" the vehicle being tracked. Also, for the samples made with traffic traveling at free-flow speeds, vehicles were abandoned which proved to be traveling significantly faster or slower than the average speed of traffic.

In the event that the target vehicle moved to the right lane in apparent preparation to exit, the observer often was able to switch tracking to another vehicle that had been just behind or ahead of the original vehicle in the same lane (and used the newly adopted vehicle to complete the sample). This was necessary because in some cases six or seven minutes had been invested in the tracking of a specific vehicle, and it was important to avoid wasting that time where possible.

It should also be pointed out that speeds were not tracked for very slow moving queues (densities over 120 / MWCOG samples only). Instead, density runs were made at 5 or 10 minute intervals, such that later on the ground the same vehicles could be found in succeeding sets of density photos; this allowed computation of speeds and associated densities.

DATA PROCESSING

After each flight, a topographic map was prepared for each zone which showed the starting and stopping points for each tracked car. Measurements were then made of the segment length (distance traveled). Then each tracked vehicle was entered into the computer database, including:

- 1. vehicle description
- 2. time-of-day
- 3. initial lane and subsequent lane changes
- 4. precise travel time (from stopwatch or time-lapse photographs)
- 5. density-photo preference, if any (default was to average the before- and after- density samples)
- 6. any special notes pertaining to that vehicle.

After the photos had been processed, each set of overlapping "density" photographs was taped together into a "mosaic" that showed each entire segment. Then vehicles in the required lane(s) were counted, listed by "car", "truck", "tractor-trailer" and "bus". These totals were translated into passenger-car equivalents (PCE's) using the following values:

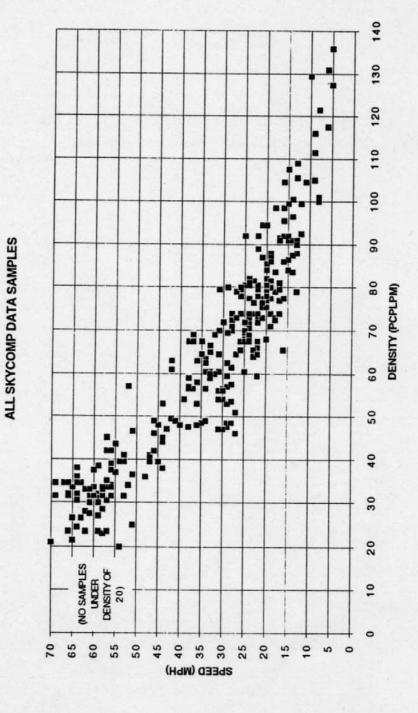
Vehicle type:	PCE's:
cars	1
trucks	1.5
tractor-trailers	2.0
buses	1.5

(It should be noted that the distinction between "cars" and "trucks" could not be cleanly made, since there are many varieties of light and heavy pick-ups (both covered and uncovered). In general, a pick-up or van had to be at least twice the size of an average-sized car to be considered a "truck".)

PCE's were then divided by segment length to calculate densities. These density samples were then matched to corresponding speed samples; each speed/density data pair was then plotted on the chart.

CALIBRATION OF THE VAN AERDE MODEL

The latest draft of the MWCOG paper describing the calibration of the Van Aerde Speed / Density Model for the Washington D.C. metropolitan area is provided next. This paper was authored by Paul DeVivo, the member of MWCOG staff who performed the analysis.



Van Aerde Model DRAFT -- 15 Feb 96

The main advantages to a single-regime model are that boundaries between regimes do not have to be defined; and curves from adjacent regimes do not have to be spliced at the boundaries. A single-regime model allows for a more subjective and repeatable calibration process. This will be is especially true if more data from the high-speed end of the curve is ever incorporated into this process.

The disadvantages to this particular model are that it expresses this project's independent variable as a function of the dependent variable; and that it is a nonlinear function. These disadvantages make performing the initial calibration more difficult. However, once SAS programs for the task are written, they can be used again usually with a minimum of effort.

The procedure for calibration was as follows: 1) The model's equation was coded into a spreadsheet so that the shape could be defined by recognizable parameters: two points that the curve passes through, the free-flow speed, and the speed at capacity. By overlaying this curve with the scatter plot of the observations, initial estimates of the parameters were made. 2) The initial parameter estimates, the equation, and the observations were used in a SAS PROC NLIN job to machine-calibrate the parameter estimates. 3) A second SAS program translated the calibrated equation into a look-up table that expresses speed as a function of density. 4) The results of the SAS work were imported into a spreadsheet for plotting and for calculation of prediction intervals.

Two outstanding technical issues related to this procedure are determination of the free-flow speed, and calculation of prediction intervals.

The free-flow speed for best fit can be determined by the PROC NLIN program, as are all other parameters. Due to the lack of data at the low-density region of the model, PROC NLIN returns a very high free-flow speed. Additional data from MD SHA was used to calculate a free-flow speed for general application on the Beltway. The calibration of the model presented here resulted from forcing the free-flow speed to match the SHA data analysis.

The prediction intervals shown in the current plot were calculated after the model was translated. This may have not been appropriate. PROC NLIN calculates prediction intervals directly as it calibrates the model. Those prediction intervals express density as a function of speed, however. Work is in progress to translate them, and to otherwise arrive at the most appropriate method of determining prediction intervals.

Since a single-regime model is more suitable in a computerized process, and for lack of significant difference in performance, the Van Aerde model is preferred over earlier approaches examined by MWCOG staff and presented before subcommittees.

Van Aerde Single Regime Model DRAFT--2 May 1996 This model was developed by Michael Van Aerde and described in TRB Paper No. 950802. It differs from the models already presented in two significant respects: 1) The Van Aerde model expresses headway or density as a function of speed instead of speed as a function of density; 2) The Van Aerde model's single regime is continuous for the entire speed range from jam to free-flow.

The model is:

$$D = 1 / (c1 + c2 / (Sf - S) + c3 * S)$$

where:

D = Density (vehicles/lane/mi)

Sf = Free-flow speed (mph)

c1, c2, c3 = coefficients

S = Speed (mph) -- INDEPENDENT VARIABLE

The model was calibrated for local use by MWCOG staff. Maryland SHA ATR data from stations on the Capital Beltway was used to determine the free-flow speed. Skycomp aerial speed/density observations were used to calibrate the coefficients.

The calibration resulted in the curves shown in the attached graphics: Speed vs. Density; Flow Rate vs. Density; Speed vs. Flow Rate; and Speed Residuals vs. Density.

The coefficients required to plot the Density vs. Speed curve are 0.00512, 0.0144, and 0.000342, respectively. The free-flow speed is 67 mph. All trucks were weighted as 2.5 cars. The upper and lower bounds shown on this plot are 95% prediction intervals.

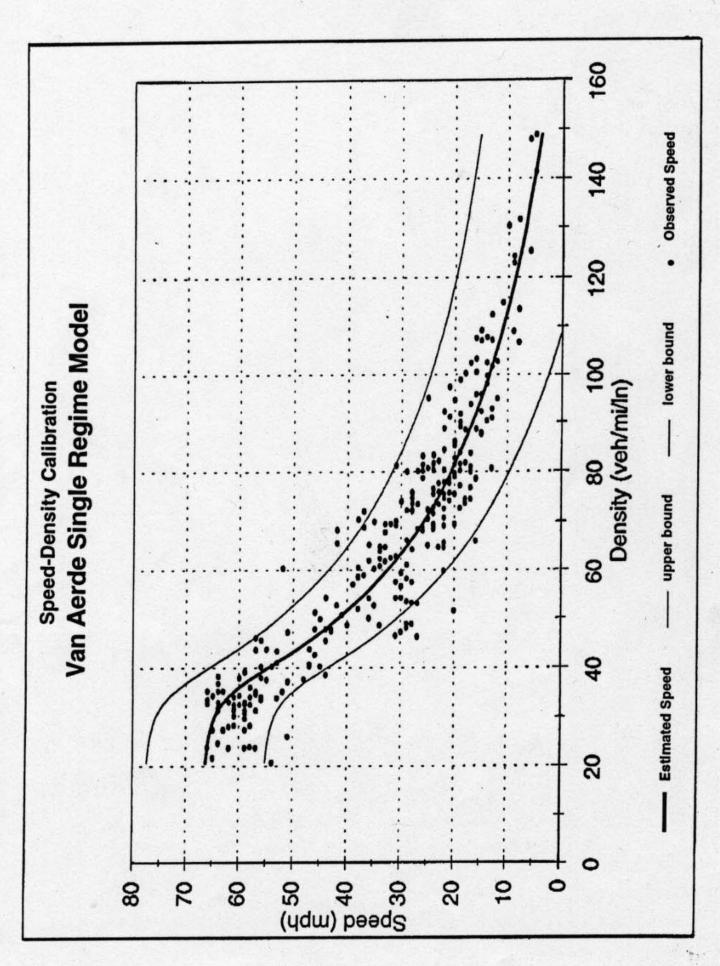
Speed-Density Calibration Van Aerde Single Regime Model

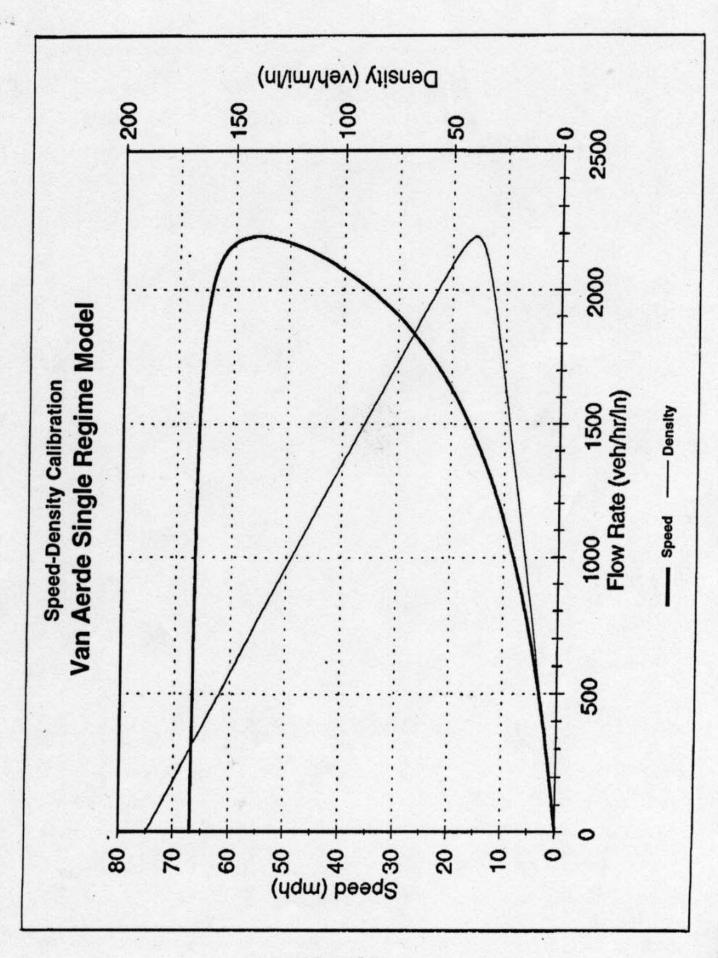
free-flow spd = 67 mph / c1 = 0.00512 / c2 = 0.0114 / c3 = 0.000342

DENS (veh/ln															
VOLUME (veh/ln/hr)	0	1,328	1,661	1,946	2,144	2,190	2,189	2,153	2,094	2,025	1,954	1,880	1,806	1,731	
SPEED (mph)	67.0	66.4	65.8	64.6	61.3	22.8	54.7	47.8	41.9	36.8	32.6	28.9	25.8	23.1	
DENSITY (veh/ln/mi)	0	20	25	30	32	<u>68</u>	40	45	09	99	09	9	02	22	
	free-flow					capacity									

														0 jam
VOLUME (veh/ln/hr)	1655	1580	1503	1425	1350	1271	1197	1117	1043	963	882	810	729	0
SPEED (mph)	20.7	18.6	16.7	15.0	13.5	12.1	10.9	9.7	8.7	7.7	8.9	0.9	5.2	0
DENSITY (veh/In/mi)	80	85	06	96	100	105	110	115	120	125	130	135	140	187

Draft 15 February 1996





APPENDIX C

FLIGHT DIRECTORY

FLIGHT NO.	DATE	DAY OF WEEK	AM / PM
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	Sept 10 Sept 11 Sept 20 Sept 20 Sept 21 Sept 25 Sept 25 Sept 26 Sept 26 Sept 27 Sept 27 Sept 27 Sept 28 Oct 2 Oct 2 Oct 2 Oct 3 Oct 3	Monday Tuesday Thursday Thursday Friday Tuesday Wednesday Wednesday Thursday Thursday Thursday Thursday Thursday Thursday Thursday Truesday Wednesday Wednesday Wednesday	Evening Morning Morning Morning Morning
16 17 18	Oct 4 Oct 4	Thursday Thursday Thursday	Evening Morning Morning